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**PREHISTORIC QUARRYING AT SOUTH PAINT ROCK CHERT QUARRIES,
BIGHORN MOUNTAINS, WYOMING:
AN ASSESSMENT OF LITHIC PROCUREMENT AND REDUCTION
STRATEGIES**

by

Kyle D. Wright

Presented in partial fulfillment of the

requirements for the degree of

Master of Arts


The University of Montana

2002

Approved by



Thesis Committee Chair



Dean, Graduate School

12-31-02

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Prehistoric Quarrying at South Paint Rock Chert Quarries, Bighorn Mountains, Wyoming:
An Assessment of Lithic Procurement and Reduction Strategies

Chairman: William C. Prentiss, Ph.D.



The ongoing goal of the archaeological investigations at South Paint Rock Chert Quarries, located in the Bighorn Mountains of northern Wyoming, is to investigate the role of prehistoric quarrying in the northwestern Plains by examining any evidence as to the role of lithic technological organization, and to study high altitude land-use systems utilized by prehistoric Native Americans of the Northwestern Plains and the Rocky Mountains. This project was designed to further our knowledge of (1) lithic quarry site formation processes and lithic tool production sites; (2) develop a better understanding of technological organization of lithic procurement in hunter-gatherer economies; and (3) to aid in the understanding of Great Plains and intermountain hunter-gatherer cultures.

The significance of the chert quarries at South Paint Rock (SPRCQ) is that they contain sizable stratified deposits allowing an unusual opportunity to study prehistoric quarrying variation through time. This rare chance allows us to take a closer look at any possible changes in procurement strategies utilized by prehistoric northwestern Plains hunter-gatherers, as well as examine how these people exploited chert as a raw material for tool manufacture. Relevant questions to these processes are: (1) are quarry pits the result of single episode events or more commonly associated with multiple independent events; (2) if multiple quarrying events contributed to the formation of the archaeological record of SPRCQ, can these events be divided from the stratigraphic record of the quarry pits and associated berms; (3) do lithic reduction assemblages reflect *in situ* activities or are they the result of specific quarrying activities such as cleanup, natural deposition or erosion, or other processes; (4) what lithic reduction activities took place in context with the quarry pits and how does this differ from other areas of the SPRCQ site; and (6) what tool production, use and discard strategies were in place during the different occupations of the site.

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CHAPTER ONE

Introduction

The University of Montana's 1998 summer archaeological field school, was held at the South Paint Rock Chert Quarries (48BH245). The continuing goal of the archaeological investigations at South Paint Rock Chert Quarries (SPRCQ), located in the Bighorn Mountains of northern Wyoming (Figure 1), was to investigate the role of prehistoric quarrying in the northwestern Plains by examining any evidence as to the role of lithic technological organization, and to study high altitude land-use systems utilized by prehistoric Native American economies of the Northwestern Plains and the Rocky Mountains. A further desire of this project was to better understand and possibly clarify the roles of (1) lithic quarry site formation processes and lithic tool production sites; (2) develop a better understanding of technological organization concerning lithic procurement within hunter-gatherer economies; and (3) to aid in the development of the understanding of Great Plains and intermountain hunter-gatherer cultures.

The chert quarries at South Paint Rock are significant in that they contain sizable stratified deposits allowing an atypical opportunity to study prehistoric quarrying variation through time. This rare chance to view quarrying activities allows us to take a closer look at any possible changes in procurement strategies utilized by prehistoric northwestern Plains hunter-gathers as well as examine how these people exploited chert as a raw material for tool manufacture. As well as allowing a glimpse of quarrying operations, this research provides us the opportunity to examine the archaeological record at higher altitudes within the Bighorn

FIGURE 1: PROJECT AREA LOCATION

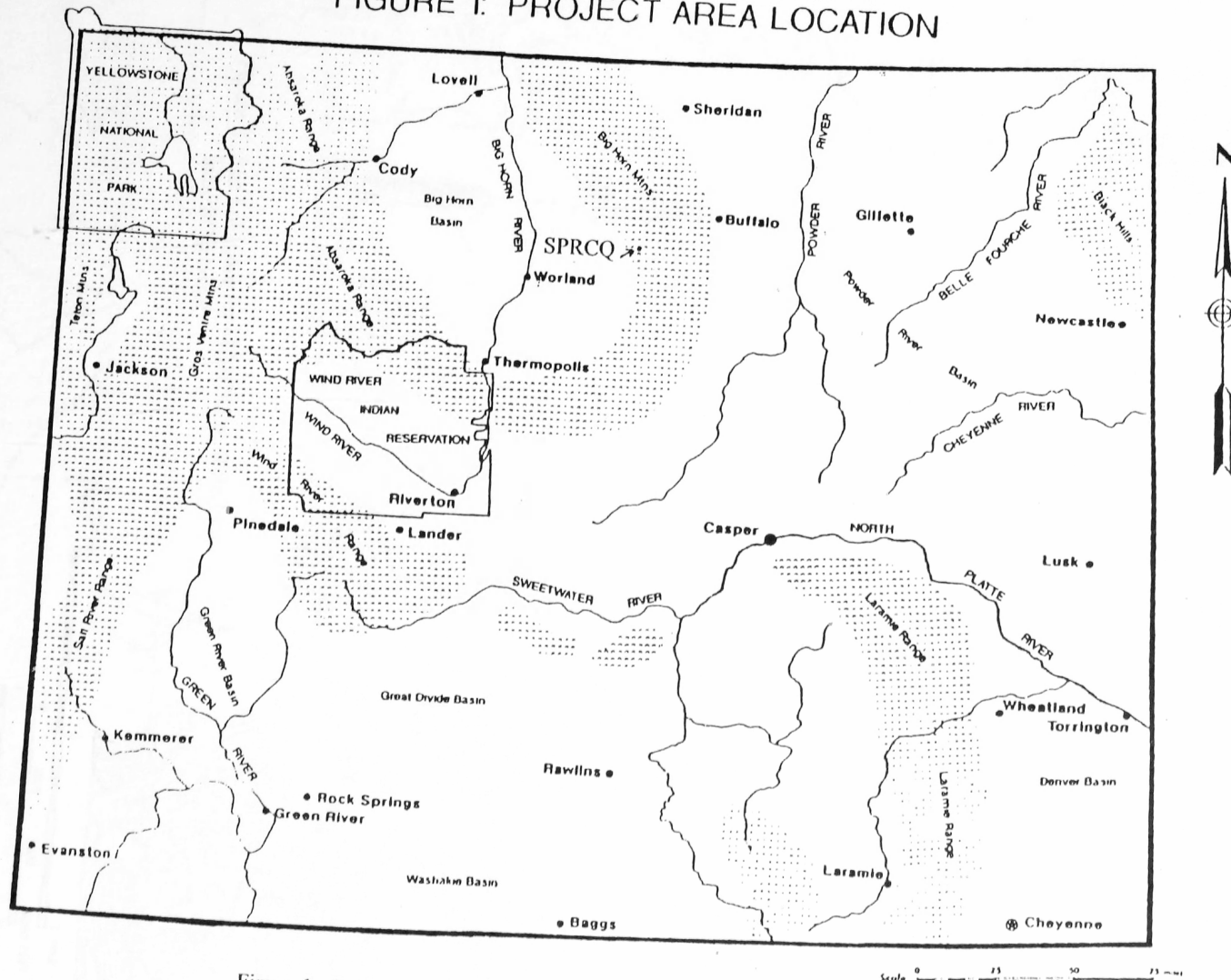


Figure 1. South Paint Rock Chert Quarries, Wyoming

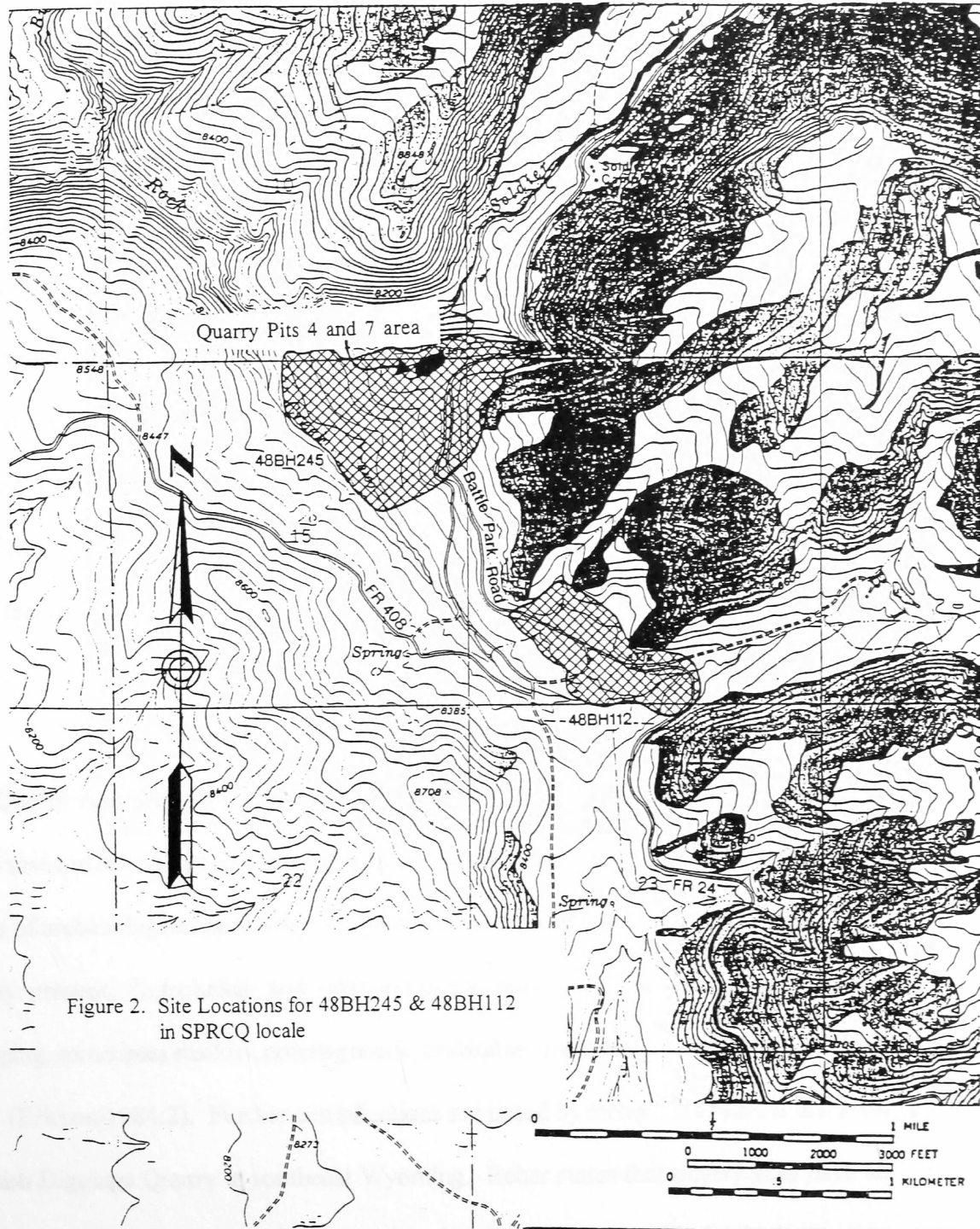


Figure 2. Site Locations for 48BH245 & 48BH112
in SPRCQ locale

Mountains, an area often neglected in comparison to archaeological research conducted on the slopes and foothills of these mountains as well as within the adjacent Bighorn Basin.

The archaeological investigations, held during the summer of 1998, took place during an eleven-day session involving the excavation and mapping of two separate quarry pits located within the previously defined site boundaries of 48BH245 (Figure 2). The University of Montana field school excavation at SPRCQ was focused on exposing stratigraphically intact components within the excavation units, placed within the quarry pits and on the outside of the pits on the waste berms. The excavation strategy was also focused on detecting and defining any adjacent lithic raw material processing areas to better define the extent of raw material extraction and tool manufacture conducted by prehistoric populations utilizing this resource.

Description and Results of Previous Work

Quarry sites present a problem when trying to identify temporally diagnostic living surfaces that can be associated with quarrying and lithic reduction activities. With their large amounts of archaeological materials quarry sites present a difficult task to archaeologists in that they present, "...technical and methodological limitations imposed by a shattered, overlapping, sometimes shallow, nondiagnostic, undatable, unattractive, redundant...material record" (Ericson 1984:2). Further complications are noted by Reher (1991) from his work at Spanish Diggings Quarry in southeast Wyoming. Reher states that quarry sites have an added degree of difficulty in interpretation due to insufficient stratigraphic depth, destruction of site integrity by collectors and previous investigations, and in his words, "massive

accumulations that include at least some examples of almost any type or stage of reduction.”(Reher 1991:275)

One of the earliest archaeological investigations conducted at the SPRCQ was by Julie Francis (1983) as a part of her dissertation on lithic procurement in the Bighorn Basin and surrounding Mountains. After performing a surface inventory at 48BH245 and throughout the area, Francis concluded that Madison chert at the SPRCQ and elsewhere throughout the region was procured in a direct fashion through true quarrying methods. She also asserted that materials produced from this high quality Madison chert tended to be curated and conveyed greater distances than other lesser cherts found throughout the area. Light and Prentiss’ (1993) work at the SPRCQ suggested that this site contains a continuous stratified archaeological record encompassing several square miles. Their research has identified specific feature types including large quarry pits and hearths. Also identified were numerous lithic artifacts which are characteristic of quarrying, food processing, and lithic tool production (Prentiss et al. 1994).

The initial subsurface investigation at the SPRCQ, conducted by Light and Prentiss in 1992 and 1993, was directed toward demonstrating any variation in lithic reduction activities and stratigraphy within the site (Light and Prentiss 1993; Prentiss et al. 1994). The result of these investigations was the designation and mapping of two particular locales (48BH245 and 48BH112). Based on landform characteristics, 60 50x50cm shovel test units and 17 1x1m units were excavated within the site boundaries of 48BH245 and 48BH112. As a result of this investigation 12,101 lithic artifacts were recovered with a total of 248 lithic tools and a small amount of bone. Projectile points recovered from the excavations were

dated from as early as 8,500 B.P. to as late as 500 to 1,000 B.P. (Light and Prentiss 1993). Soil profiles taken during this investigation did not demonstrate any significant disturbance of artifacts through erosional or depositional events. Sediments in the project area ranged from typically .5 to 1 meter in depth and were graded as ranging from loams to silt loams in the upper levels to clay loams to clays in the lowest levels. All artifacts and faunal remains were determined to have been in their original stratigraphic contexts throughout the project area.

Distributional patterns were recognized within the lithic assemblages recovered from the 1992 excavations. Stage 2/3 bifaces (Callahan 1979) were spread comparatively evenly throughout the project area. Also represented in the assemblage was a wide array of small flake tools. Specialized tools such as notches and denticulates were found to be clustered around quarry pit areas. Bipolar and prepared cores were also found to cluster close to quarry pits. Initial analysis of the assemblages and stratigraphy of the site has shown lithic reduction through time diverged from an earlier focus on early to middle stage biface production to a later emphasis on intensive core reduction and early biface production. An early hypothesis, based on these patterns, led the investigators (Light and Prentiss 1992) to propose that the quarry pits were the outcome of a relatively late occupation.

Research Design

The current research focus at SPRCQ was developed to examine and address three different archaeological problems: (1) formation processes of lithic scatter and quarry sites; (2) the study of quarry sites in relation to hunter-gatherer lithic technological organization;

and (3) the evolution of Northwestern Plains hunter-gatherer cultures.

Site Formation Processes

Archaeological site formation processes constitute a wide array of events that define the appearance and context of the current archaeological record (Schiffer 1987). Defining the formation processes at work in the SPRCQ requires concentrating on geomorphology, taphonomy, as well as the formation of lithic debitage and flake tool assemblages produced in association with quarrying activities. Relevant issues to these processes are: (1) are quarry pits the result of single episode quarrying events or more commonly associated with multiple independent quarry events; (2) if multiple quarrying events contributed to the formation of the archaeological record of SPRCQ, can these events be divided from the stratigraphic record of the quarry pits and associated berms; (3) do lithic assemblages reflect *in situ* activities or are they the result of specific quarrying activities such as cleanup, soil management, natural deposition or erosion, or other processes; (4) what lithic reduction activities took place in context with the quarry pits and how does this differ from other areas of the SPRCQ site; and (5) what tool production, use and discard strategies were in place during the different occupations of the site.

Quarry Sites and Hunter-Gatherer Technological Organization

Quarry sites are acknowledged for having the potential to aide in our understanding of the role of lithic technology in hunter-gatherer economic systems (Ericson 1984; Reher 1991; Bamforth 1992). Unfortunately, their difficulty in analysis and unreliable stratigraphic

contexts have limited their value in the past. As new models and theories come to light concerning tool reduction, transport strategies, and lithic raw material procurement (Elston 1992; Kuhn 1994) we are better able to interpret quarry assemblages and devise more fitting hypotheses for the investigation of quarry sites. In particular, Elston (1992) proposes that energy exerted in tool production, transport and use is reduced in order to increase the efficiency in which organic resources are obtained and processed (Elston 1992:32-33).

Northwestern Plains Prehistory

The analysis of quarry sites requires a broader perspective than merely considering the role of lithic raw material quarrying, tool production, transport and use. These activities are a part of the greater whole that shapes archaeological landscapes in the northwest Plains. The central most question concerning the SPRCQ data is what was the relationship between quarrying, communal bison hunting and complexity in Plains hunter-gatherer social organization? Bamforth (1988) has posited that with an increase in annual rainfall, range conditions favored an increase in bison populations leading to larger herd aggregations. This increase in available biotic resources in turn favored an increase in the size of aggregated bison hunting groups. Historical examples have shown that success in communal bison hunting introduced opportunities for status achievement by way of selection to greater leadership roles, accumulation of material wealth, increased trade opportunities, and acquisition of multiple spouses. In his article, *Large Scale Lithic Quarries and Regional Transport Systems on the High Plains of Eastern Wyoming*, Reher (1991) asserts that patterns of affluent bison hunting can be recognized in the archaeological record not only

from bison kill sites but also in tipi ring village and quarry sites. Quarry sites reflect the means by which hunter-gatherers “geared-up” for large communal hunts or trade expeditions with lithic resources. It can be hypothesized that the intensification of quarrying activities concurred during periods of optimal range conditions and large herd aggregations and communal bison hunting correlated with the Late Archaic (2100-1600 BP) and the Late Prehistoric to Protohistoric periods (post 600 BP) in Frison’s (1991) Northwest Plains chronology. The connection between Northwest Plains forager societies and the widespread network of Northern and Central Plains populations is another factor to be considered. Various researchers have concluded that the increase in populations and social complexity in the late Prehistoric period favored an aggrandized exchange network which increased the amount of goods exchanged between Northwest Plains foragers and the semi-sedentary horticulturalists farther east (Wood 1967; Spielmann 1986; Brink & Dawe 1989; Boyd 1998). Boszhardt (1998) has proposed that trade of lithic materials from the Madison formation was active since at least Besant/Hopewell times. Increased trade networks and intensified gearing up for communal bison hunts may have been a catalyst in the increase of quarrying activities of high quality lithic materials like Madison formation cherts.

Field Research

The objective of the 1998 field school was to continue mapping the upper portion of the SPRCQ site area. Along with this, excavation units were to be placed on the interior, berm and exterior portions of at least two quarry pits. By placing the units in this way it was envisioned that this would provide stratigraphic profiles which could be used in assessing the

cultural and temporal correlations between quarrying events and lithic reduction and transportation activities. Survey and mapping of SPRCQ excavations was completed employing a transit and stadia rod to plot the archaeological excavation units and features, as well as contour and topographic features on the site plan map. Excavation units were arranged using a one meter grid system. Vertical control during excavation was dictated by naturally occurring stratigraphic levels. One feature, a vertical walled pit, was revealed during excavation and was exposed horizontally. A plan map was drawn which indicated the size and location of all rocks and artifacts recovered from the feature. Photographs were taken of the feature both prior to and after the excavation. Sediment samples were collected from all stratum present in each unit capitalizing on natural and cultural levels to aid in correlation and analysis of stratigraphy at the site. The collection of sediment samples will assist in determining depositional regimes, soil transformation and weathering processes, sediment formation, and chemical content and the likely effects on artifacts and floral/faunal assemblages. No dateable pieces of charcoal were recovered for analysis, but one bone tool was recovered and submitted for radiocarbon dating.

Laboratory Research

The analysis of lithic assemblages collected from the SPRCQ centered on experimentally tested methods used to delineate debitage and flake tool assemblage variability (Hayden & Hutchings 1989; Prentiss 1993). The intent of the analysis was to afford the investigators with an initial indication of the range of lithic reduction activities (i.e., flake culling, flake tool use-reuse-discard cycles, trampling effects) which play an influential role

in the character of assemblages. Conclusions drawn from this analysis as to the cultural processes that were responsible for this patterning will be dealt with in later chapters.

Analysis of the faunal remains collected from the excavations was directed toward taxonomic identification and reconstruction of taphonomic processes. Sedimentary studies were pursued to understand formational environments with *in situ* archaeological remains. Attention was paid to sediment type, contacts, grain size, color, bedding, and sorting. The analysis of the feature was centered around descriptions of feature morphology and the examination of feature contents.

Results

The 1998 University of Montana Field School at the South Paint Rock Chert Quarries (48BH245) yielded data from five excavation units located in association with two distinct quarry pits. Soil samples were collected and analyzed for granulometry and measured to determine phosphorus levels. Faunal artifacts recovered included one rib fragment identified as a possible quarrying tool and one carnivore canine. The bone quarrying tool, recovered from Quarry Pit 4, was used to obtain an AMS date of ca. A.D. 1300-1400. Lithic materials recovered from the excavations totaled 14,468 artifacts. The highest proportions of these are flakes, followed by cores, hammerstones and a diverse assortment of flake and chipped stone tools.

The goal of this thesis is to investigate the role of prehistoric quarrying in the northwestern Plains by clarifying the role of lithic quarry site formation processes and lithic tool production, develop an understanding of technological organization of hunter-gatherer

lithic procurement economies and seeks to aid in the understanding of Great Plains and intermountain hunter-gatherer cultures.

Chapter Two will examine the cultural and environmental context of the northwestern Plains. Chapter Three will delineate the field season at South Paint Rock concerning methods and context of the site and excavation units. Chapter Four will detail the analyses of the lithic assemblages collected during the summer excavations and in Chapter Five conclusions will be drawn from the results of the statistical analyses.

CHAPTER TWO

Cultural and Environmental Context

This chapter will focus on the cultural and environmental background of the South Paint Rock Chert Quarries (SPRCQ). This section will deal with the paleoenvironmental context of the region and outline a cultural chronology relevant to this area of the northwestern Plains. The fundamental emphasis of the work being conducted at SPRCQ has been based on the interpretation and understanding of the archaeological assemblages and discerning how they relate to the economics of chert quarrying, therefore, this chapter will be directed toward creating an outline of ecological conditions existing over the past 11,000 years and of the variability of foraging strategies utilized by prehistoric hunter-gatherers during this time. Due to the importance of quarrying and other forms of lithic procurement to foraging economies (cf. Francis 1983) other theories concerning the study of quarrying and raw material usage will also be introduced in this chapter. While the central geographic focus of this chapter will be the Northwest Plains (Frison 1991), there will also be a short review of the cultural chronology of the Middle Missouri region. With its large populations and complex cultures, the influences of the Middle Missouri region had on the hunter-gatherer cultures of the Great Plains is undeniable. It is conceivable that these groups had a great influence on the formation of alliances, trade patterns, and overall foraging strategies. In concurrence with this line of thought, the changing cultural patterns witnessed in the late Prehistoric period may have had considerable effects on the modes of lithic procurement, tool production and conveyance and usage within the region.

CONTEMPORARY ENVIRONMENT

Topography

The Bighorn Mountains extend approximately 120 miles in length by 30 miles in width (Prentiss 1985:3). Surrounding mountain ranges include the Pryor Mountains to the north (in southern Montana) and the Absaroka Mountains to the west. The Bighorns form a natural barrier between the Bighorn Basin located to the west and the Powder River Basin located to the east (Osterwald 1978:5).

The Bighorn range is drained by a myriad of perennial streams originating at high elevations near the central spine of the range. The western streams are tributaries of the Bighorn River, which in turn flows north into the Yellowstone river. The eastern portion streams drain into either the Little Bighorn River, the Powder River or the Tongue River (Light & Prentiss 1993:8).

The Bighorn Mountains are formed as an asymmetrical anticline containing a Pre-Cambrian core overlain with Paleozoic and Mesozoic sedimentary rock. The rock on the western slope gradually descends into the Bighorn Basin while the eastern portions drop steeply into the Powder River Basin (Francis 1983:38). Just to the east of the project area, in the central portions of the Bighorn range, the Pre-Cambrian granites and metamorphic rock are exposed. Dates from these formations extend back to 2.4 billion years (Blackstone 1988:91).

The Bighorn Mountains were formed during the Laramide Orogeny, circa 70 million years ago. This mountain range reaches its zenith at Cloud Peak with an elevation of 13,165

feet (Blackstone 1988:14).

Geology

The South Paint Rock Chert Quarries are situated on the western flank of the Bighorn Mountains in North central Wyoming. The elevation of the quarries is roughly 8,000 to 9,000 feet above sea level. Site 48BH245 sits atop of a terrace and ridge system overlooking Soldier, Buckskin Ed and the South Fork of Paint Rock Creeks. The quarries within the project area sit atop the Bighorn Dolomite Formation, stratigraphically next to the Madison Limestone Formation. Bighorn Dolomite was derived in the Ordovician age (approximately 435 million years ago). Love and Christiansen (1985) describe this formation as consisting of a grey massive siliceous dolomite and locally dolomitic limestone. The Bighorn Dolomite Formation is around 450 to 500 feet in thickness. This Formation was likely generated in an aerated shelf environment (Ver Ploeg & De Bruin 1985:6). The Madison Limestone Formation dates from the Mississippian Age (330-360 million years ago) and is composed of a blue-grey massive limestone and dolomite grading to a grey, cherty limestone and dolomite. This formation ranges from 800-500 feet in thickness and was also deposited in an aerated shelf environment (Ver Ploeg & De Bruin 1985:7). The Madison Limestone overlays the Bighorn Dolomite. The Madison formation contains a strain of high grade opaque to translucent cherts developing in both tabular and nodular form.

Exposed bedrock within the project area fluctuates between a cream and light brown in color. In texture the bedrock is finely crystalline to sucrosic with intermittent nodules of chert. Weathering causes the color to change to a dark brown to grey with pitting on the

exposed surfaces.

Fauna

The Bighorns have supported an abundance of mammals, known both historically and prehistorically. Large herbivorous mammals include the moose (*Alces alces*), elk (*Cervus elaphus*), mule deer (*Odocoileus hemious*), whitetail deer (*Odocoileus virginianus*), bison (*Bison bison*), bighorn sheep (*Ovis canadensis*), pronghorn (*Antilocarpa americana*), beaver (*Castor canadensis*), snowshoe hares (*Lepus americanus*), whitetail jackrabbits (*Lepus townsendi*), and porcupines (*Erethizon dorsatum*). Large carnivores include grizzly bear (*Ursus arctos*), black bear (*Ursus americanus*), mountain lions (*Felis concolor*), wolves (*Canis lupus*), coyotes (*Canis latrans*), red fox (*Vulpes fulva*), and badgers (*Taxidea taxus*).

A list of small mammals, herbivores and carnivores combined, includes river otters (*Lutra canadensis*), muskrat (*Ondrata zibethica*), pika (*Ochotona princeps*), mountain cottontail (*Sylvilagus nuttalli*), long-tailed weasel (*Mustela frenata*), short-tailed weasel (*Mustela erminea*), striped skunks (*Mephitis mephitis*), yellowbelly marmots (*Marmota flaviventris*), raccoon (*Procyon lotor*), bushytailed woodrat (*Neotoma cinerea*), least chipmunk (*Eutamias minimus*), thirteen-lined ground squirrel (*Citellus tridecemlineatus*), red squirrel (*Tamiasciurus hudsonicus*), northern flying squirrel (*Glaucomys sabrinus*), northern pocket gophers (*Thomomys talpoides*), Wyoming pocket mice (*Perognathus fasciatus*), western harvest mice (*Reithrodontomys megalotis*), deer mouse (*Peromyscus maniculatus*), northern grasshopper mice (*Ondrata zibethica*), boreal red-backed voles (*Clethrionomys gapperi*), meadow voles (*Microtus longicaudus*), mountain voles (*Microtus*

montanus), long-tailed voles (*Microtus longicaudus*).

Common birds indigenous to the Bighorn Mountains include the golden eagle (*Aquila chrysaetos*), turkey vulture (*Cathartes aura*), red-tailed hawk (*Buteo jamaicensis*), raven (*Corvus corax*), crow (*Corvus brachyrhynchos*), black-billed magpie (*Pica pica*), great grey owl (*Strix nebulosa*), kestrel (*Falco sparverius*), blue grouse (*Dendragapus obscurus*), ruffed grouse (*Bonasa umbellus*), mallard (*Anas platyrhynchos*), red-shafted flicker (*Colaptes cafer*), Clark's nutcracker (*Nucifraga columbiana*), grey jay (*Perisoreus canadensis*), Stellar's jay (*Cyanocitta stelleri*), water ouzel (*Cinclus mexicanus*), and the black-capped chickadee (*Parus atricapillus*).

Flora

Five dominant biotic zones are represented within the Bighorn Mountains. These zones starting from the lowest elevation and ascending upwards: the Upper Sonoran, the Transitional, the Canadian, the Hudsonian, and the Arctic/Alpine zones (Cary 1917). The biotic zones can be further subdivided into vegetative communities including the sagebrush community, the mixed conifer forest, juniper-mountain brush community, the lodgepole pine forest, the ponderosa pine forest, the aspen community and the Douglas fir community (Prentiss 1985:9).

The edges of the Bighorns are generally encompassed by the juniper-mountain brush community with characteristically small trees and shrubs. Dominant vegetation includes sagebrush (*Artemisia tridentata*), mountain mahogany (*Cercocarpus ledifolius*), and juniper (*Juniperus scopulorum*). The sagebrush community is located above the juniper-mountain

community. Above this community in elevation we move into the sagebrush community. The main plants of this biotic region are sagebrush (*Artemisia tridentata*), rabbit brush (*Chrysothamnus nauseosus*), prickly pear cactus (*Opuntia polyacantha*), and various forbs and grasses. As elevation approaches 7,000 feet sagebrush becomes the predominate shrub and Douglas fir (*Pseudotsuga menziesii*) and Ponderosa pines emerge in larger numbers (Frison & Bradley 1980:7). The sagebrush community can rise to elevations as high as 10,000 feet. The SPRCQ's occupy the sagebrush community at an elevation of 8,200 to 8,400 feet above sea level.

Flora observed at 48BH245 consists of sagebrush (*Artemisia tridentata*), rabbit brush (*Chrysothamnus nauseosus*), squawbush (*Rhus trilobata*), shrubby cinquefoil (*Potentilla fruticosa*), Rocky Mountain juniper (*Juniperus scopulorum*), foxtail barley (*Hordeum jubatum*), blue grama (*Bouteloua gracilis*), meadow chickweed (*Cerastium arvense*), junegrass (*Koeleria cristata*), forget-me-not (*Eritrichium nanum*), shooting star (*Dodecatheon dentatum*), lupine (*Lupinus* spp.) bistort (*Polygonum bistortoides*), dandelion (*Taraxacum officinale*), pasque flower (*Anemone patens*), mountain avens (*Geum triflorum*), arrowleaf balsamroot (*Balsamorhiza sagitta*), larkspur (*Delphinium nuttallianum*), white phlox (*Phlox longifolia*), sulphurflower (*Erigeron umbellatus*), wild onion (*Allium ceruuum*), stonecrop (*Sedum lanceolatum*), wild geranium (*Geranium richardsonii*), groundsel (*Senecio douglasii*), strawberry (*Fragaria ovalis*), thistle (*Carduus nutans*), and several varieties of lichens.

Climate

A wide array of climates prevail in the Bighorn Mountains and surrounding basins. The Powder River Basin, ranging in elevation from 3,750 feet up to 5,000 feet above sea level, is classified as a semi-arid environment. The Bighorn Basin, also ranging in elevation between 3,750 feet up to 5,000 feet above sea level, is categorized as an arid to semi-arid environment. Temperature ranges in both basins vary seasonally from 100° (38°C) in the summer down to -30° (-36°C) in the winter (Frison & Bradley 1980:6).

The foothills start at 4,500 to 5,000 feet in elevation. Many peaks in the Bighorn range are between 10,000 and 12,000 feet with Cloud Peak the tallest at 13,175 feet above sea level. The climate of the foothills is varied, lower elevations have basin like temperatures and drier conditions with a transition to cooler and wetter environs as you rise in elevation. Temperatures in the mountains fluctuate as much between day and night as they do between summer and winter. Temperatures can dip to -65° (-54°C) in the winter with temperature in the eighties or warmer in the summer (Craig & Gilbert 1981:6).

PALEOENVIRONMENTS

Ecological research in the Bighorn National Forest has shown shifts in environmental conditions since the late Pleistocene (ca. 12,000 B.P.), which have fluctuated between periods of stability and change. Attempts to delineate discrete paleoenvironmental periods within the Holocene has been complicated by numerous incidents of within and between period climatic variation (cf. Grayson 1993). These fluctuations within paleoenvironments of the Plains had distinctive effects on the cultural evolution of prehistoric hunter-gatherer groups, most

importantly on the relationships between the inhabitants of this region and their food procurement strategies. To better understand the significance of the effects of changing paleoclimatic regimes on accessibility and availability of central subsistence resources obtainable to Plains horticulturalists and foragers, this section will introduce a basic outline as to the paleoenvironmental sequence of the Northwest Plains/Middle Rocky Mountains region. The first section of this outline will concentrate on presenting the major paleoenvironmental sequences advanced by researchers over the past forty years. Second the discussion will then focus on an abbreviated look at recent research on soils, dune, vegetation, faunal, glacial, and paleolake chronologies followed by an integration of the data to construct a comprehensive working paradigm of the regional paleoenvironmental changes which in turn holds implications for understanding the changes in the cultural evolution of prehistoric hunter-gatherer groups within the Plains region.

Paleoenvironmental Chronologies

The paleoenvironmental sequence of the Great Plains between the Holocene and Pleistocene can be arbitrarily dissected at a date of 10,000 B.P. (Hopkins 1975). This date corresponds to the period of the extinction of Pleistocene mammals, the conclusion of the Younger Dryas cold period, the withdrawal of Lake Bonneville from the higher Gilbert level, and the proliferation of a grassland environment across the expanse of the Great Plains. This random division between the Pleistocene and Holocene should not be seen as the commencement of contemporary environments. Holocene environments have been shown to be highly irregular in both moisture and temperature regimes. These fluctuations had a

major effect on the distribution of faunal and floral resources as well as influencing human adaptations within the region.

Antevs (1955) classified the Holocene paleoclimatic sequence under the rubric of Neothermal, which was further subdivided into three intervals identified as the Anathermal, Altithermal and, Medithermal. The Anathermal, starting circa 10,000 B.P., was defined as a period of high moisture levels and temperatures somewhat cooler than today's. Toward the end of this sequence, temperatures started to rise and precipitation levels fell culminating in the Altithermal around 7,000 B.P. By the date of 4,500 B.P. the climate was in transition from the warm and dry conditions of the Altithermal to the cooler and moister conditions of the Medithermal. Since its inception, Antevs's model, although largely accurate, has been refined and refurbished with new data. The Anathermal period was redefined as warmer and dryer after the discovery of a misinterpreted ash layer in the Summer Lake sequence that dated back to the Pleistocene instead of the Holocene as proposed by Antevs (Grayson 1993:216). With further research the Altithermal and Medithermal have been shown to have been much more variable than purported by Antevs.

Drawing comparison from the Blytt-Sernader sequence of European paleoclimatic episodes (cf. Zeuner 1952) and in conjunction with North American paleoclimatic research, Wayne Wendland and Reid Bryson developed a progression of "step-like" episodes for North America (Bryson & Wendland 1967; Bryson et al. 1970; Wendland & Bryson 1974; Wendland 1978). This new sequence contains the Late Glacial (pre-Holocene), Pre-Boreal, Boreal, Atlantic, Sub-Boreal, Sub-Atlantic, Scandic, Neo-Atlantic, Pacific, and Neo-Boreal episodes. Patterns within the Great Plains region affiliated with these events joined cool wet

summers and cooler, compared to contemporary temperatures, winters to the Late Glacial. Increasing warmth was ascribed to the Pre-Boreal, Boreal and Atlantic episodes. The Sub-Atlantic and Sub-Boreal witnessed a recurrence of cooler temperature with an increase in moisture during the former episode. Moisture levels, at their peak during the late Sub-Atlantic, gave way to the dryer conditions of the Scandic period. The Neo-Atlantic was characterized by warm temperatures and increasing moisture. This episode was followed, in turn, by an abrupt decrease in moisture levels during the Pacific. A return to a wetter and cooler climate was the result of the Neo-Boreal episode.

Devising a six-episode sequence, Pielou (1991) condensed the late Pleistocene and Holocene climatic cycles with emphasis on the continental variation of North America. Pielou's sequences comprise the Late Pleistocene, Hypsithermal (as per Deevey and Flint 1957), Neoglaciation, Little Climatic Optimum, Little Ice Age, and the contemporaneous warming events. The inception of the Hypsithermal on the Great Plains, circa 7,000 to 8,000 B.P., is characterized by a general warming trend throughout the whole of North America (Pielou 1991:270). The next episode, starting around 5,000 B.P., was the Neoglacial. Pielou defines this period by the increased amounts of glacial activity brought about by cooler temperatures and increased moisture levels. The Neoglacial period was disrupted by the increased warmth and locally specific aridity of the Little Climatic Optimum, lasting from 1,800 to 650 B.P. A transition back to similar conditions found in the Neoglacial period was classified as the Little Ice Age (650 to 100 B.P.). The emphasis of Pielou's climatic model is based on the variability of climates in both a regional and temporal basis.

Eckerle's (1994) regionally based research into the paleoenvironmental context of the

Middle Rocky Mountains, was established upon the previously mentioned work of Pielou and upon geoarchaeological research conducted within several intermontane basins of Wyoming. Eckerle bisects the Hypsithermal of Pielou (1991) into two periods tending toward reduced moisture levels and increasing temperatures. These periods were designated as the Early Holocene and the Altithermal (after Antevs 1955). Eckerle's Early and Middle Neoglaciation periods coincide with Pielou's Neoglaciation episode with their characteristic cooler temperatures and increase moisture levels. In Eckerle's model the label of Little Altithermal is substituted for Pielou's Little Climatic Optimum with no difference in interpretation of climatic conditions. Eckerle also borrows the term Little Ice Age to characterize the period between 500 to 100 B.P. The Eckerle and Pielou sequences are useful in the sense that they provide a general background to paleoenvironmental conditions. Other than Eckerle's sequence, paleoclimatic research has failed to address paleoclimatic variation within each episode particular to the Middle Rocky Mountain region. An explanation of this episodic variation is needed to develop a valid paleoclimatic sequence. Therefore, the succeeding sections will establish the fundamental data needed to develop this model.

REGIONAL PALEOENVIRONMENTAL RESEARCH

Soil and Dune Chronology

Reider (1990) has classified late Pleistocene soils on the northwestern Plains as Paleo-aquolls. He proposes these organically rich and water saturated soils nourished large communities of sedges, scattered woodlands and grasses. The soils representing the period

from 10,000 to 8,000 B.P. are depicted by Reider as indicative of an oscillation between cool and warm periods. Reider contends the soils of latter periods (between 8,000 to 5,000 B.P.) were formed during very dry climates with high levels of saline and calcium carbonate constituents. In conjunction with this claim, Reider believes that vegetation fostered in these soils would need to consist of salt tolerant grass and bushes in the lowlands with sagebrush communities being dominant in the uplands. A wide range of soil types are identified by Reider within the Neoglacial period (post 5,000 B.P.) ranging between cool/wet and warm/dry regimes. Two soil types were identified by Reider et al. (1988) at the Dead Indian Creek site in northwest Wyoming. These soils were classified as a grassland soil (dating pre-5,000 B.P.) and a forest soil (post-5,000 B.P.) which is suggestive of the demarcation between the Hypsithermal/Altithermal and the Neoglacial episodes.

Dune conditions throughout this period have been studied by Ahlbrandt (1983). Ahlbrandt contends that high activity levels in dune conditions are present after 10,000 B.P. with a shift toward stability starting around 8,000 B.P. and lasting to roughly 6,000 B.P. Elevated dune activity occurs again after 6,000 B.P. and continues until 4,000 B.P. Ahlbrandt et al. (1988) believe that the time between 4,000 and 1,800 B.P. was a relatively stable period in aeolian dune formation and movement. High activity recurred from 1,800 to 500 B.P. and was replaced by a stable period from 500 to 100 B.P.

Vegetation Chronologies

Paleobotanical studies, traversing a wide geographic range extending from the eastern Great Basin through the Rocky Mountains to the eastern border of the Great Plains can be

consolidated to develop a vegetation chronology for the Northwest Plains. The easiest formula involves combining the alternating steppe and grassland environments within this region. Based on pollen sequences for the northeast portion of the Great Basin, Currey and James (1982) and Mehringer (1985) have developed complex vegetational sequences for the eastern Great Basin. Similar sequences were established for the Teton and Yellowstone National Parks region and eastern Idaho by Whitlock (1993) and Beiswenger (1991) respectively. Bright (1966) conducted an influential paleobotanical study at Swan Lake, Idaho. Bright's work focused on the ecotone between mountain slope forest and basin plains. Bright contended that prior to 10,000 B.P. this area was predominately vegetated with by *Pinus*. Lesser numbers of *Artemisia*, *Amaranthus*, *Chenopodiaceae*, and *Sarcobatus* were also present but in fluctuating levels. Beiswenger's data supported Bright's work by demonstrating high numbers of *Artemisia* and *Graminae* in the basins and *Picea*, *Pinus* and *Juniperus* on the forested mountain slopes and foothills.

As indicated by Bright (1966), the period between 10,000 to 8,000 B.P. was influenced by a general warming trend which was detectable through a rapid boom in *Artemisia* levels in conjunction with a decrease in *Pinus* at Swan Lake. A *Cheno-Am/Artemisia* steppe environment is proposed by Beiswenger at this time. Currey and James charge that after 10,500 B.P. sagebrush steppes encroach onto the lower mountain slopes and depose the coniferous forests.

By 7,500 B.P. *Artemisia*, *Graminae*, *Compositae*, and *Amaranthaceae* communities were on the rise as opposed to a decrease in *Pinus* and *Picea* populations. Between approximately 7,500 and 5,000 B.P. basin shadscale and sagebrush communities as well as

mountain grasslands are shown to be expanding (Currey & James 1982; Mehringer 1985; Beiswenger 1991). Forest fires are noted by Whitlock (1993) as evidence for a strong pattern of burgeoning Douglas fir, Lodgepole pine and mixed spruce forests.

From 5,000 to 4,000 B.P. the drier xeric conditions reverted. Whitlock (1993) contends that this time was the genesis of modern forests of *Pinus*, *Picea* and *Abies*. By 2,500 B.P. Bright (1966) has shown an expansion of *Pinus* and *Graminae* populations with a corresponding decline in *Artemisia*, *Sarcobatus*, and *Amaranthaceae*. A cooling trend, is noted by Currey and James (1982) circa 3,000 B.P. at the glacial-lacustral-pluvial maxima. This conclusion is supported by evidence showing an expansion of sagebrush steppes into former shadscale communities and conifer forests encroaching onto grassland and sagebrush steppe environments. This cooler weather pattern was interrupted just subsequent to 2,000 B.P.

After this date, Bright (1966) has shown a general resurgence of *Chenopodiaceae*, *Sarcobatus*, and *Artemisia* with a decline in populations of *Pinus*, *Picea* and *Graminae*. By 1,500 B.P. Currey and James (1982) and Mehringer (1985) have observed an increase in grassland populations. Bright's (1966) data from Swan Lake shows a *Pinus* community increases at approximately 1,200 to 1,000 B.P. Currey and James (1982) again recognize a period similar to conditions present in the late glacial-lacustral-pluvial maxima. Circa 600 B.P. Currey and James (1982) recognize an abundant rise in grassland habitats.

Key paleobotanical studies conducted within the Great Plains are those of Wright (1970) engaged in studies from the central Plains, King with research concentrated in the east-central Plains and Midwest, Markgraf and Lennon (1986) for work in the Powder River

Basin, and Wedel's (1986) summary of Wendland and Bryson's (1974) research in the Upper Republican area of the west-central Plains.

Prior to the Holocene, circa 10,000 B.P., a rapid proliferation of grasslands has been noted. High amounts of *Pinus* forests and *Artemisia* steppes were recognized by Markgraf and Lennon (1986) in pollen levels from the Powder River Basin. Within the Midwest, King (1980) proposes spruce forests were succeeded by pine, fir, alder and birch forest. Wedel (1986) has proposed that the average mean temperatures were several degrees Celsius cooler than temperatures today.

In the Powder River Basin in the period between 10,000 and 8,000 B.P. was marked by diminishing numbers of *Pinus* and *Graminae* with growing numbers of *Chenopodiaceae*, *Artemisia*, *Compositae* and *Sarcobatus* (Markgraf & Lennon 1986). Within the central Plains, Wright (1970) observed an increase in upland prairie plants. The Midwest oak forests are noted to have been encroaching into areas formerly dominated by fir and pine species (King 1980). Wedel (1986) has shown that the Upper Republican area at this time maintained a continental climate with seasonably warm temperature in the summer and cold temperature in the winter.

Between 8,000 to 4,000 B.P. the central Plains were drying out (Wright 1970). This pattern was also seen on the northwest Plains. Markgraf and Lennon (1986) characterize the Powder River Basin as an environment high in species of *Chenopodiaceae*, *Artemisia*, *Compositae* and *Sarcobatus*. By 6,200 B.P. King (1980) believes that the Midwestern oak forests were succeeded by grasslands. Within the Plains, prevailing hot and dry westerlies, in conjunction with the rain barrier created by the Rocky Mountains, were causing extreme

dry conditions (Wedel 1986).

After 4,000 B.P. environments were cooling and increased levels of moisture were present. Wedel (1986) notes a marked increase in storm activity after 2,900 B.P. producing wetter summers and tumultuous winters in the central Plains. With a relatively low count on pollen types between 6,000 and 3,000 B.P., Markgraf and Lennon (1986) note a burgeoning of pollen types after 3,000 B.P. *Pinus*, *Populus*, *Artemisia*, *Chenopodineae* and *Graminae* types reach their zenith by 2,000 to 1,700 B.P. in the Powder River Basin. Midwestern hardwood species are recognized by King (1980) to have made a comeback by 3,200 B.P.

Increased moisture and cooling patterns occurring during the late Plains archaic were temporarily disrupted between 1,800 and 1,700 B.P. and again around 500 B.P. by a slight warming trend. High amounts of *Chenopodineae*, *Artemisia*, and *Sarcobatus* pollen types in Markgraf and Lennon's (1986) data indicate a comparatively arid environment. Wedel (1986) indicates that warm, dry air is controlling weather conditions from 1,600 to 400 B.P. on the central Plains, disrupted temporarily by higher moisture levels around 1,225 to 800 B.P. On the central Plains Wedel describes this climatic event as causing expanding steppe environments (between 1,600-1,225 B.P.), declining steppe and developing prairies (1,225-800 B.P.), and an increase in steppe environments (800-400 B.P.).

After 400 B.P. a shift in climates toward cooler and moister conditions prevailed. Data from Wedel's (1986) research alludes to cool summers and cold autumns in the central Plains. This information is disputed by Bamforth (1988). He concludes that temperatures were influenced by cold winters conditions but ranges in temperatures varied from year to year between 550 to 100 B.P. Bamforth also argues for increased levels of moisture on the

northwestern Plains which is substantiated by increased levels of *Pinus*, *Juniperus*, *Graminae*, and *Artemisia* and decreased levels of pollen from *Chenopodinae* and *Sarcobatus* in Markgraf and Lennon's (1986) data from the Powder River Basin.

Faunal Chronology

The culmination of the Pleistocene, offset by the dawning of the Holocene, saw a dramatic transition in faunae on the Northwest Plains. These changes will be outlined, concentrating on the record nearest to the Pleistocene/Holocene boundary.

Hoffman and Jones's (1970) article, *Influence of Late-Glacial and Post -Glacial Events on the Distribution of Recent Mammals on the Northern Great Plains*, produced an influential comprehensive study focusing on the faunal record of the late Pleistocene. This work was added to and improved by Walker (1982) in his paper, *Early Holocene Vertebrate Fauna*. Walker provides a detailed list of Northwest Plains species reflected in paleontological and archaeological sites contemporaneous with the terminal glacial period of the late Pleistocene (12,000 to 10,000 B.P.): *Panthera leo atrox*, *Canis dirus*, *Mammuthus mammothus*, *Arctodus simus*, *Miracinonyx trumani*, *Platugonus compressus*, *Equus equus*, *Equus conversidens*, *Bison bison bison*, *Navahoeocerus*, *Ovibovine indet.*, *Ovis canadensis catclawensis*, *Symbos symbos*, *Camelops cf. hesternus*, *Martes noblis*, and *Hemiauchenia sp* (Walker 1982:276). Other species of Carnivora, Rodentia, Artiodactyla and Insectivora have been discerned in Pleistocene deposits, but this wide array of species can still be found residing in or near the region.

Walker (1982), in conclusion with Graham (1979), hypothesizes that the environment

of the late Pleistocene was that of a steppe-savannah. In addition, Graham (1979) proposes that riparian zones were the dominant environment along drainages while grassland environments were in evidence in the uplands. Pleistocene faunal diversity has been depicted as higher than that of the Holocene, which bears considering that the collective environment of the Pleistocene was different from any modern counterparts. Various researchers (Guthrie 1984a, 1984b; Harris 1985; and Kelly & Todd 1988), have proposed that the Pleistocene environments were distinguished by moderate seasonal change mixed with a high diversity of floral and faunal communities.

The start of the Holocene witnessed the emergence of new environmental zones. Climatic patterns were changing, seasonality became more distinct and plant communities started developing exclusively in specific spacial zones. Guthrie (1984a) proposes that increased seasonality led to shortened growing seasons with abbreviated plant-protein crests. This made it difficult for large herbivores to consume satisfactory amounts of foodstuffs to satisfy dietary requirements let alone contend with increasingly formidable winters. The expansion of plants with antiherbivore defenses coupled with spatially zoned vegetation increased the difficulty for herbivores to meet dietary requirements. By 10,000 B.P., an estimated 35 mammalian genera had gone extinct due to sudden environmental change.

Glacial Chronology

Glacial advances, from the late Pleistocene to the Holocene, have had dramatic effect on the Rocky Mountains. Glacial activity in the northern Rockies has been noted by various researches dating from the Younger Dryas episode. Along the Front Range in Colorado there

was the Santanta advance (Benedict 1973), the Late Pinedale readvance from the Yellowstone region (Currey and James 1982), and in the Wind River Range of Wyoming there was the Temple Lake advance (Davis 1988). All of the aforementioned advances show evidence of long periods of recession with slight intervals of small readvances. These episodes of advance followed by retreated lasted until approximately 8,000 B.P. in the Colorado Front Range, the Wind River, the Medicine Bow, and in the Teton Ranges of Wyoming (Benedict 1973; Davis 1988).

Glacial activity resumed after 5,000 B.P. in the Triple Lakes are in the Colorado Front Range (Benedict 1973). In Wyoming at this time, Davis (1988) has identified the following advances: the Early Neoglacial (Absaroka Range), the Disaster Peak (Medicine Bow Range) and, the Indian Basin (Wind River Range). A slight episode of glacial advance taking place late in the Neoglacial from 2,400 to 1,500 B.P., dubbed the Audubon advance, is evident within portions of the Colorado Front Range and areas of the Wind River and Teton Ranges of Wyoming.

Glacial activity subsides from 1,500 to 500 B.P. followed by a series of advances during the Neo-Boreal or Little Ice Age. These advances occurred throughout Wyoming and portions of Colorado. In the Medicine Bow Range of Wyoming there was the Cirque Moraines advance, the Late Neoglacial advance occurred in the Absaroka Range, and in the Wind River Range there was the Gannett Peak advance. The Colorado Front Range was represented with the Arapaho advance (Benedict 1973; Davis 1988).

Paleolake Chronology

The Great Salt Lake located in the eastern portions of the Great Basin provides researches with and excellent insight to paleolake chronologies (Currey 1990). Environmental factors have affected the fluctuating levels of this lake from the late Pleistocene to the Holocene. Lake levels reached their zenith around 12,000 B.P. and the dropped to a low before rising back up to a postglacial high just after 10,000 B.P. These levels remained fairly constant until the Neoglacial episode when the lake arrived at its highest levels for the Holocene soon after 5,000 B.P. Pielou (1990) observed that during the Little Climatic Optimum lake levels again sank low followed by higher levels during the Little Ice Age within the Late Prehistoric period.

PALEOENVIRONMENTAL SUMMARY

A summary of the aforementioned data from late Pleistocene and Holocene paleoenvironments can now be constructed to explain cultural variation in the Northwest Plains region. This model, borrowed from and developed by Prentiss (unpublished 1999), has taken into account and incorporates environmental factors such as soil, dune, vegetation, faunal, glacial and paleolake chronologies to develop a picture of the environmental variables that have influenced the cultural practices of the earliest inhabitants of North America in general and the northwestern Great Plains specifically. The concepts and terminology of Bryson and Wendland (1974) are relied on for this model but Pielou's (1991) more comprehensive terminologies which relate better to the pervasive climatic trends across North

America.

The Late Glacial period in North America has been depicted as a comparatively cool climate with high moisture levels. Summers were cool in contrast to contemporary temperatures. Winters were generally mild. Prior to 10,000 B.P. glaciers were active. Stable soils, paleosols, supported riparian habitats and burgeoning grasslands. The diversification of previously homogeneous ecological zones, the development of seasonality with greater extremes in average mean temperature, and new defense mechanism derived by plant species, coincided to bring approximately thirty-five mammalian species to extinction in North America during the early Holocene. The most notable extinctions affecting human populations were those of the Pleistocene mega-fauna; mammoths, species of large bison, horses, and camels. Carnivore extinctions included the short faced bear, American Lion and the dire wolf.

The early Holocene, included within the Hypsithermal by Pielou (1991), is presumed to be a period of transition characterized by fluctuations and variations in weather patterns, precipitation levels and environments. Data relates that dune activity was increasing and soil indicators oscillate between warm/dry and cool/wet periods. Glacial activity rises around 8,000 B.P. Vegetation better suited to xeric conditions thrive and out compete plants suited to moister environments.

Warm and dry climates, from the late Hypsithermal, contribute to increased dunal activity and soil instability. Sagebrush and Shadscale communities dominate the landscape of the Great Plains and Rocky Mountains. The reduction of grassland habitats aids in the extinction of large herbivores which in turn leads to the decline of predator populations.

The early Neoglacial is similar to the early period except for slightly cooler temperatures and wetter climates. Dune activity remains high, fluctuating soil conditions are still evident, and glaciers are advancing through the mountain valleys. Vegetation types remained constant from the previous period. By 4,000 to 1,600 years ago, a more noticeable tendency towards higher precipitation and cooler temperatures evolves. Glacial advances reach their peak by 2,000 B.P. After this time dunes stabilize and vegetation patterns again shift back toward grasslands in the plains and basins and pine and spruce forests in the mountains. The expansion of high yielding grasslands and the apex glacial advances were likely to have contributed to large aggregations of herbivores around 2,000 B.P.

The Little Climatic Optimum (1,600 to 600 B.P.) signaled a change in the cooler and moister conditions of the Neoglacial. A warmer and drier climate is evident in increased dune activity, the retreat of glaciers, and the recolonization of Shadscale/sagebrush steppe communities into grassland habitats. Large herbivore populations on the Plains dwindled and were consequently less accessible to human populations.

Environmental conditions during the Little Climatic Optimum were characterized by glacial retreat, unstable soils, dune activity and the expansion of xeric adapted plant communities and environments. Temperatures throughout the Little Climatic Optimum continued to decrease as the Little Ice Age approached.

The Little Ice Age ushered in an increase in glacial activity, the stabilization of dunes, and the extension of grassland environments into the basins and plains and pine and spruce forests into the mountains, both formerly dominated by sagebrush steppe habitats. Higher levels of moisture favored more productive grasslands which in turn led to an increase in large

herbivore populations.

Over the past one hundred years patterns have returned to a similar state of the seen during the Little Climatic Optimum. Reduced levels of precipitation combined with less productive vegetation have opened the way for the expansion of shadscale and sagebrush communities, most noticeably within the inter-montane basins of the Rocky Mountains.

PREHISTORIC CULTURAL CHRONOLOGY

This summary of the prehistory of the Northwest and Northern Plains is intended to bring to light cultural adaptations employed by the prehistoric inhabitants of these areas. This synopsis of northern Plains prehistory will be accomplished by focusing on key sites and by drawing from earlier documentation of prehistoric lithic procurement (quarrying activities) and use strategies.

Middle Missouri cultural chronologies, from the late prehistoric period, will be included in this summary due to their possible role in lithic materials exchange networks between these regions (Bozhardt 1998). It has also been speculated (Brink & Dawe 1989; Boyd 1998) that the rise of complex cultures in the Middle Missouri region may have had an effect on Northwest Plains foraging societies, specifically in the areas of trade networks and the emergence of social competition.

THE PALEOINDIAN PERIOD

The Plains region contains many significant sites which have added to our knowledge of subsistence strategies and technologies of paleoindian peoples. This information has allowed researchers to draw inferences on a wide range of topics including, economics (Kelly & Todd 1988; Todd 1987), ethnicity (Frison & Grey 1980; Frison 1992), group dimensions (Frison & Todd 1986,1987; Frison 1991), mobility (Kelly & Todd 1988), subsistence economics (Todd 1987; Kelly & Todd 1988), and technological organization (Ingbar 1992). Inferences have been drawn as to quarrying activities throughout the Paleoindian period but as of yet our knowledge is incomplete and based on inference from detailed site investigations.

Clovis Complex

Controversy has raged for years over the topic of a pre-Clovis peopling of North America. Although various investigations have hinted at the possibility of an early occupation within the Plains and Rocky Mountains (cf. Miller and Dort; Stanford 1979) and elsewhere throughout the New World (Whitley & Dorn 1993), general perceptions within the archaeological community recognize the Clovis Complex as the earliest culture represented within the archeological record on the Northwest Plains. In spite of the fact that this record is limited, a scattering of significant sites have been excavated within the central Rocky Mountains and northwestern Plains.

A relatively late radiocarbon date of $10,600 \pm 90$ B.P. was obtained from the Dent site, in north-central Colorado, in comparison to one of the earlier dates for the Clovis Complex,

collected from the Lindsay Mammoth site in eastern Montana, at $11,925 \pm 350$ B.P. (Frison 1991:25). Frison estimated the most likely range for Clovis occupations falls between 11,500 to 11,000 B.P. (Frison 1991:24).

Various contexts have been recorded in association with Clovis sites. These range from cache sites to lithic reduction sites to animal kill and processing sites. The most distinctive trait of the Clovis Complex is its hallmark fluted projectile points and bifaces found association with large extinct fauna (Howard 1990; Bradley 1991). This assortment of site types are typified by meat and tool caches as represented by Richey-Roberts (Mehringer 1988), Fenn (Frison 1991), and the Colby site (Frison & Todd 1986), mammoth kill sites like Colby (Frison & Todd 1986) and Lange Ferguson (Hannus 1985, 1990), Lindsay (Frison 1991), and the Union Pacific (McGrew 1961); lithic reduction sites represented by the Dent site (Stanford 1979) and the Sheaman site at the Agate Basin locale (Frison 1982); and burials from the Anzick site (Lahren & Bonnicksen 1974).

Clovis people have been identified as big game hunters, in particular hunters of mammoth (Frison & Todd 1986; Hannus 1990). Various researchers have proposed the use of “insurance caches” by Clovis people to circumvent shortages when faunal or lithic resources were difficult to procure (Kelly & Todd 1988). The Colby site, positioned in north-central Wyoming, supports this hypothesis with two distinct stacks of mammoth bones, identified by Frison and Todd (1986) as insurance meat caches. The Colby site has been dated from $11,200 \pm 220$ to $10,864 \pm 141$ B.P. Lithic raw materials used to produce the projectile points recovered from the Colby site were of Phosphoria and Madison cherts.

Goshen and Folsom Complexes

The epitome of stone tool production was achieved through the emergence of Folsom technologies. Folsom projectile points are identified by their heavy flutes and complex pressure flaking. The Goshen complex, similar to Folsom but lacking the center channel flake, has been identified as an intermediary between Clovis and Folsom technologies on the northwestern Plains (Irwin-Williams et al. 1973; Todd & Rapson 1988; Frison 1991). Dates from significant Folsom sites range from $10,980 \pm 150$ at the Indian Creek site in southwestern Montana to $10,080 \pm 330$ from the Hanson site in north-central Wyoming (Frison 1991:25). The Mill Iron site, containing a Goshen component, ranges from $11,570 \pm 170$ to $10,600 \pm 90$ B.P. (Frison 1991:25). Unfortunately, the relationship between Clovis, Goshen and Folsom is sketchy at best and needs to be better defined.

The Hanson site, an archetypal Folsom site, dates between 10,700 to 10,300 B.P. An elaborate lithic reduction strategy has been hypothesized from materials recovered from this site from the eastern borders of the Bighorn Basin in Wyoming (Frison & Bradley 1980; Ingbar 1986, 1992). Ingbar has proposed that the method of lithic reduction found at the Hanson site indicates a resource utilization strategy designed to foresee temporary raw material shortages and alleviate these shortages by controlling resource use and procurement in time with organized group movements. By maximizing the use life of lithic resources, prehistoric foragers would assure themselves of a supply of lithic raw materials when in areas of low or unknown resources. Most notable to this project is a number of tools recovered from the Hanson site were produced from cherts from the Madison formation. Other significant sites classified within the Folsom complex include Hell Gap (Irwin-Williams et al.

1973), Agate Basin (Frison & Stanford 1982), Lindenmeire (Wilmsen & Roberts 1984), and Carter/Kerr-McGee (Frison 1984).

People of the Folsom complex were generally believed to be big game hunting specialists, comparable to the Clovis people, except their hunting was primarily focused on large extinct species of bison (Frison 1978; Hoffman & Ingbar 1988). This premise has been challenged by various researchers (cf. Chase 1987; Kornfeld 1988) who assert that small game and plants also played an important part in Folsom peoples diet.

Agate Basin and Hell Gap Complexes

Sequentially, Agate Basin and Hell Gap Complexes follow those of Folsom and date from 10,500 to 9,500 years ago (Frison 1991). Influential sites with Agate Basin and Hell Gap components include Hell Gap (Irwin-Williams et al. 1973), Casper (Frison 1974), Jones-Miller (Stanford 1978), Agate Basin (Frison & Stanford 1982), and Carter/ Kerr-McGee (Frison 1984). All of the previous sites, with the exception of Hell Gap, are examples of bison kill sites.

Frison characterizes Agate Basin projectile points as “long and narrow with a thick, lenticular cross-section” (Frison 1991:57). Frison maintains that these points were potent hunting equipment which were agreeably designed for reworking upon breakage (Frison 1991:58). Hell Gap points were characteristically wider than Agate Basin points and more developed in the shoulders. Whatever the differences may be, they were both exceptionally adapted to dispatching large fauna (Frison 1991:62).

Recent reevaluation of radiocarbon dates from Folsom, Agate Basin, Hell Gap, and

early Alberta/Alberta-Cody sites have shown these complexes to be contemporaries for a short span of time. The overlapping between complexes corresponds to the Pleistocene/Holocene transitional period which arguably encouraged an elevated degree of diversity and experimentation in technological strategies.

Alberta, Alberta/Cody, and Cody Complexes

Based on large stemmed projectile points recovered from the Hell Gap site (Irwin-Williams et al. 1973) and the Hudson-Meng bison kill site (Agenbroad 1978a) Frison (1991) has advanced the premise of an Alberta cultural complex. Likewise, projectile points recovered from the Horner site have led Bradley and Frison (1987) to put forward the concept of an Alberta-Cody cultural complex. Frison (1991) proposes that the Alberta and Alberta-Cody complexes fall within the late Paleoindian period with dates ranging from $8,990 \pm 190$ B.P. at Hudson-Meng (Alberta component) to $10,060 \pm 220$ at the Horner site (Alberta/Cody component). Frison (1991) cites the variation in Alberta, Alberta/Cody points manufacture to be grounds for their own cultural complex designation. Alberta and Alberta/Cody projectile points have been characterized as having abrupt shoulders and wide stems compared to points from earlier complexes.

The Cody Complex is represented at Scottsbluff (Schultz & Eiseley 1935), Olson-Chubbock (Wheat 1972), Medicine Lodge Creek and Laddie Creek (Frison 1976, 1991), and at the Horner site (Frison & Todd 1987). Cody Complex artifacts are recognized by Scottsbluff and Eden projectile points and the unusual Cody knife (Bradley 1991). These artifacts exhibit wide stems, compared to the blade width, and precise collateral pressure

flaking.

The Horner site, dating from 9,500 to 9,000 B.P., is a late fall to early winter bison kill site. While the method used to dispatch the bison is unknown, Kelly and Todd (1988) propose that the low butchery evident within the bison bed is an indicator of Paleoindian mobility and a selective “gourmet” use strategies from large kill sites. Most notably, Madison formation cherts comprise more than 14% of the lithic tools recovered from Horner I and Horner II.

Late Paleoindian Complexes

Complexity in the Paleoindian archaeological record begins to increase around the time of the Cody Complex. Frison (1991) designates the time spanning from 9,000 to 7,500 B.P. as the Late Paleoindian period. Researchers (Frison & Grey 1980; Frison 1992) have proposed that during this marked time of diversification, Paleoindian populations started expanding and residing exclusively in foothill-mountains and intermontane basins. Evidence supporting the argument for the divergence of late Paleoindian projectile points can be found in a wide range of contexts and environmental regions. Cody complex materials, characterized by their wide stems and collateral pressure flaking are found within intermontane basins. Lusk and James Allen points represented by lanceolate points with concave bases and parallel oblique flaking are found in context with bison kills. Within a foothills-mountain setting, found in association with an assortment of faunal remains, we find a wide array of lanceolate stemmed and notched points (Lovell Constricted, Pryor Stemmed, Angostura, and Frederick). Frison (1992) notes that materials recovered from foothill-

mountain assemblages are often found in relation to caves and rockshelters, while basin materials are not.

Frison (1992) has cited the frequent use of Madison formation cherts in a foothill-mountain context. Frison observes, "The common strategy at the higher elevations was to recover and select pieces from the sources and remove them to the nearest meadow or spring source for further reduction in size and selection of quality. In some cases extensive quarrying was done, while in other places the materials were apparently available on the surface and in arroyo cuts." (Frison 1992:330).

Numerous significant Late Paleoindian sites have been recorded from the northern Plains region to the central Rocky Mountains. These sites are Angostura (Hughes 1949), Red Smoke (Davis 1953); Lime Creek (Davis 1962); Medicine Lodge Creek (Frison 1976); Mummy Cave (McCracken et al. 1978); Clary Ranch (Myers et al. 1981); Lookingbill (Frison 1983); Bush Shelter (Miller 1987); Allen (Bamforth 1991); and Paint Rock V (Frison 1992). Prentiss and Light (1993) also discovered evidence for a late Paleoindian component at the South Paint Rock Chert Quarries.

The archaeological record clearly indicates a transition towards complexity in prehistoric technologies appearing during the Cody Complex continuing into the Late Paleoindian period. Towards the end of this period the more distinctive "Archaic" pattern of emerges and is substantiated by large variations in artifacts types and faunal assemblages found in a wide assortment of environmental contexts. This pattern of diversification roughly corresponds with Bryson and Wendland's (1967) Atlantic climatic period.

THE ARCHAIC PERIOD

The Archaic period ushered in an era of diversification in the types of subsistence strategies employed by prehistoric populations. The focus switched from the Paleoindian reliance on large game to a more general resource base focusing on readily available and abundant resources like plants and small animals (Caldwell 1958). The Early Archaic did not bring an abrupt and dramatic shift to the life ways of prehistoric foragers. Hayden (1981) has claimed that Paleoindian groups on the Great Plains were utilizing a wide range of resources with “Archaic” technologies at least 2,000 years prior to the accepted commencement of the Early Plains Archaic (7,500 B.P.). Horticultural practices never made their way into the Northwest Plains like they did in other areas of North America during the Archaic period. Archaic lifestyle are assumed to have lasted through to the Historic Period on the Northwest Plains (Frison 1991).

The Archaic on the Plains is divided into three periods by Frison (1991). The first period is the Early Plains Archaic lasting from 7,500 to 5,000 B.P. Next is the Middle Plains Archaic from 5,000 to 3,000 B.P., and finally the Late Plains Archaic extending from 3,000 to 1,500 B.P. Each period is classified according to transitions in projectile point technologies, as well as divergence in settlement patterns and resource procurement and processing strategies. The most noteworthy shifts in cultural adaptations during the Archaic period, as defined by Reeves (1990) and Frison (1991), seem to be the onset of pithouse use in the intermontane basins of Wyoming and Colorado (Early Archaic), the creation of a pemmican production technology and the use of tepees (Middle to Late Archaic), and the amplification of communal bison hunting (Late Archaic).

Francis (1997) discusses the role of the procurement of Madison formation cherts and its influence as a high quality raw material on the Archaic stone tool industry. Francis proposes that Archaic foragers would have made logistically organized trips up to high elevation locales which contained cherts of this quality due to the inaccessibility and limited surface exposure of this resource. Because of its quality and infrequency, Madison cherts would have been fabricated into prepared cores and formalized bifaces, resharpened repeatedly to extend the use life of the tool, and discarded less frequently than other cherts of lesser quality. Francis' data show that lower quality raw materials, like Morrison chert, were typically thrown away after a minimal use period.

Early Archaic

Due to an adverse environment, the Early Archaic was perceived to have been a time when prehistoric peoples abandoned Plains environments (Mulloy 1958). This opinion has since been shown to be inaccurate due to incomplete data. This time was, however, characterized by an intensification of exploitation of foothill-mountain regions and resources (Frison 1991). This assumption is in accordance with the climatic patterns manifested by the Atlantic (Altithermal) Episode. Biomass resources were reduced due to these conditions, particularly in the intermontane basins where water supplies were limited and precipitation levels lower than in the mountains. The change from lanceolate and stemmed projectile points to notched points was the most distinct innovation in the archaeological record between the earlier Paleoindian Period to the Early Archaic Period.

The Early Archaic Period coincides with the Atlantic climatic episode from 8,000 to

5,000 B.P. Radiocarbon dates retrieved from Mummy Cave range from $7,630 \pm 170$, at the early end, to $5,255 \pm 140$ at the highest Early Archaic level (McCracken et al. 1978). Other dates acquired from sites with an Early Archaic component are: Southsider Cave at $7,650 \pm 200$ (Frison 1991:30); Hawkins site at $6,270 \pm 170$ and $6,470 \pm 140$ (Frison 1991:31); and Carter Cave recorded at 4430 ± 140 (Frison 1991:32). Coincidentally, an Early Archaic component was discovered at the South Paint Rock Chert Quarries by Light and Prentiss (1993) during their investigations at 48BH245. The object recovered, from subsurface testing, was an Early Archaic side-notched projectile point.

Research into Early Archaic settlement patterns in the northwest Plains and central Rocky mountains has yielded three general habitation models the prehistoric inhabitants of these regions. First, in the marginal areas of intermontane basins and in the mountains themselves, rockshelters are intensively utilized. Important sites confirming this hypothesis are Wedding of the Waters Cave (Frison 1962), Leigh Cave (Frison & Huseas 1968), Granite Creek Rockshelter (Frison & Wilson 1975), Mummy Cave (McCracken et al. 1978), Bush Shelter (Miller 1987), Laddie Creek (Larson 1990), and Little Canyon Creek Cave (Frison 1991).

Lithic assemblages recovered from these sites show a gradual shift from lanceolate stemmed points of the Paleoindian period to the traditional Early Archaic side notched and occasionally corner notched points. Broad spectrum foraging practices are also evident in assemblages from these sites.

The second pattern, occurring primarily in the open and stable sand-dune environments of the Washakie and Great Divide Basins, and the Green River of central and

southern Wyoming, is the emergence of pithouses (McGuire et al. 1984; Harrell & McKern 1986; McKern 1987; Eakin 1987; Reust et al. 1993). Smith and Reust (1992) classify pithouses into two categories. First, there is the late winter-spring pithouse and second the late summer-fall residence. The difference is credited by Smith and Reust as being the result of a highly mobile foraging adaptation relying on a wide variety of resources as indicated from the archaeological record.

Third, bison remained as the primary resource, although in limited quantities, in the marginal areas of the Plains as seen by the evidence from sites like Hawkin in the Wyoming Black Hills (Frison 1991), the Sun River Site located in western Montana (Greiser et al. 1985) and Head-Smashed-In Buffalo Jump from southern Alberta (Reeves 1978).

The Early Archaic Period can be characterized, from the information recovered from the archaeological record, as a time of great diversification. This diversification is most evident in settlement and foraging patterns, as well as in technological and social organization. Research focusing on the Early Archaic in these regions has centered on: 1) origins of Early Archaic populations (Black 1991); 2) reasons for low populations outside of the foothill-mountain areas in the Rocky Mountains and the Plains; 3) what were the reasons for the development of pithouses; and 4) what factor contributed to the intensification of resources utilization within the intermontane basins during the Middle Plains Archaic. Research into the Early Archaic period, in general, is directed at understanding of the magnitude of the affiliation between the basin pithouse sites, foothill-mountain rockshelters and the bison kill sites.

Middle Archaic

The use of rockshelters and pithouses continues through from the Early Plains Archaic into the Middle Plains Archaic. Diversification in hunting techniques and foraging strategies continue as well. Some fundamental differences between the two periods are: 1) the development of specialized resource procurement strategies for use in the arid basin interiors; 2) the development of pemmican technology (Reeves 1990); 3) the evolution of projectile points utilizing styles from corner and side notched to lanceolate (Frison 1991; Kornfeld & Todd 1985). Notable sites from the Middle Plains Archaic are Signal Butte 1 (Strong 1935; Forbes 1985), the McLean site (Mulloy 1954; Kornfeld & Frison 1985; Kornfeld & Larson 1986), Wedding of the Waters Cave (Frison 1962), the Gant site (Gant & Hurt 1965), Leigh Cave (Frison & Huseas 1968); Paint Rock V (Frison & Wilson 1975), Granite Creek Rockshelter (Frison & Wilson 1975), Mummy Cave (McCracken et al. 1978), Sunlight Basin (Frison & Walker 1984; Ingbar et al. 1986), and Medicine Lodge Creek (Frison 1991). One Middle Plains Archaic point was recovered from sub-surface testing at 48BH245 (Light & Prentiss 1993). Frison (1991) defines the Middle Plains Archaic Period as running from 5,000 to 3,000 B.P. Radiocarbon dating has conferred a range of dates from 5530 ± 140 at Deadman Wash in Wyoming to 3180 ± 80 B.P. at Dipper Gap in Colorado.

Late Archaic

The pattern of broad spectrum foraging continued through to the Late Plains Archaic, but was challenged in part by an intensification of communal bison hunting. The introduction of new technologies onto the northern Plains, as witnessed by assemblages from Pelican Lake

and Besant bison kill sites, helped prehistoric hunters achieve the next plateau of hunting potency (Frison 1991; Reeves 1990). A major emphasis on hunting has been seen from sites radiocarbon dated from 2,000 to 1,700 B.P. in the Bighorn and Powder River Basins of Wyoming (Prentiss & Welch 1995).

The Late Plains Archaic Period spans from 3,000 to 1,500 B.P. (Frison 1991). Occupational dates spanning the Late Archaic Period are $3,089 \pm 207$ B.P. at the Yonkee site in Montana, $2,630 \pm$ B.P. at Signal Butte in Nebraska, $1,670 \pm 135$ and $1,800 \pm 140$ B.P. at the Ruby Site in Wyoming, and $1,620 \pm 165$ B.P. at Wedding of the Waters cave in Wyoming.

Besant hunters are believed to have moved onto the northern Plains from the northeast or possibly the north. With them they brought improved hunting technologies incorporating systems of elaborate drive lines and bison traps (Frison 1991). Neuman (1975) has suggested that the ancestries of the Besant people can be traced back to the Sonota Complex of eastern South and North Dakota. Besant peoples also introduced burial mounds, cord-marked ceramics, and characteristic side-notched projectile points (Frison 1991: 106). Reeves (1983, 1990) has proposed that the Besant cultures acted as intermediaries in the trade networks between Hopewellian cultures of the Midwest and the hunter-gatherer cultures of the Great Plains.

The Pelican Lake Complex precedes the Besant bison hunters on the northwestern Plains. The Pelican Lake Complex is represented in the archaeological record from the southern portions of Saskatchewan and Alberta to northern Wyoming, east to South Dakota (Hannus 1994).

Sites from the northern Plains containing Late Archaic components are Mummy Cave,

Dead Indian Creek, Medicine Lodge Creek and Wedding of the Waters Cave. Other, previously unmentioned open environment sites with Late Archaic components include Pagoda Creek (Eakin 1989), bison kill sites like Muddy Creek and Ruby (Frison 1991), and Daugherty Cave (Frison 1968) and Spring Creek Cave (1965).

LATE PREHISTORIC AND PROTOHISTORIC PERIODS **◀ NORTHWESTERN PLAINS ▶**

Frison (1991) has noted that the Late Prehistoric Period on the Northwestern Plains, running from 1,500 to 400 B.P., was a time of substantial technological and demographic change. Reeves (1990) cites the continuing importance of bison hunting in numerous areas. The bow and arrow was introduced from the north and replaces the atlatl (Frison 1991). Rock art activity increases (Francis et al. 1993), and the amount of components found in sites from this region increases dramatically (Frison 1991:111).

Data has shown that as bison hunting has remained an important activity into the Prehistoric Period. Quarrying activities were also on the rise. Reher (1991) has posited that large quarry complexes, like those at Spanish diggings in southeast Wyoming, were developed as a result of multiple occupations by task oriented groups gearing up with materials for extended bison hunting forays. Ahler (1986) has hypothesized that the organization behind quarrying and lithic procurement at the Knife River Flint Quarries shifted from a specialized tool production system favoring freehand core and biface reduction to a system favoring the production of bipolar cores and focusing on producing large flakes and bifaces. Prentiss et

al. (1994) note a shift occurring at the South Paint Rock Chert Quarries from an earlier emphasis on biface reduction to a core reduction and flake export sequence in the Late Prehistoric.

The subsequent section will diagram the chronological complexes, artifact and assemblage characteristics and present radiocarbon dates from this time period. A brief synopsis concerning theoretical debates, focusing of the interrelationships between contemporary groups from this period.

Keaster II

This complex, located in southwestern Montana and northern Wyoming, is distinguished by its small corner-notched arrow points similar in design to the dart points of Pelican Lake (Greiser 1994:38). Keaster II is recognized by Greiser (1994) as an offshoot from the Pelican Lake Complex, dating from 1,800 to 1,000 B.P. Prentiss (1998, personal communication) has alleged that Keaster II sites predominate the intermontane basins of northern Wyoming at this time. Some of the best examples of Keaster II assemblages come from Mummy Cave (McCracken et al. 1978). The Keaster II Complex mysteriously disappears from the archaeological record around 1,000 B.P., coinciding with the desertion of the mountain and basin environments by the prehistoric inhabitants circa 900 to 500 B.P. (Prentiss & Welch n.d.).

Avonlea

Recent interest in the Avonlea Complex has arisen out of the theory (Perry 1980; Wilcox 1988) that Avonlea peoples symbolize an emigration of Athapaskan speakers from the Subarctic who eventually settled in the American Southwest and gave rise to present day Apache. Reeves (1983, 1990) estimates the quality of the Avonlea lithic technology to be equal to that of the Paleoindian complexes. In addition to the characteristic side notching of arrow points other evidence from the archaeological record providing a glimpse at the products produced by the Avonlea Complex includes microblades, slab-lined hearths, extensive faunal processing, ceramics, large kill sites, and an association with trade networks (seen through exotics like dentalium).

Avonlea sites are dispersed throughout the southern portions of Canada and Montana with a low frequency of sites recorded in Manitoba, Wyoming, Colorado, Idaho and the Dakotas. Prominent sites include the Wardell Site (Frison 1973, 1988), Pictograph Cave III and Benson's Butte (Fredlund 1988), Head-Smashed-In Buffalo Jump and Lost Terrace (Davis & Fisher 1988; Reeves 1990), and Beehive (Frison 1988).

Due to the close temporal proximity of the Avonlea Complex to historically recognized Native American tribes, like the Blackfoot, Gros Ventre, Crow, Cheyenne and Shoshone, many researchers have attempted to assign ethnic identities to this and subsequent prehistoric groups. Reeves (1983) argues that Avonlea is an offshoot of the earlier Pelican Lake Complex. Reeves sees Avonlea points originating from a tradition originally located in western Alberta and British Columbia which spread to the south into the northern Plains by 1,600 to 1,500 B.P.

Morlan (1988) suggests two hypotheses for the origins of Avonlea. The first is that Avonlea is merely a link in a continual chain of the waxing and waning of a single cultural entity through time. Differing artifact complexes are merely the result of these continual changes within the tradition (Morlan 1988:306). Coinciding with Reeves' hypothesis (1983), Morlan also suggests that two traditions overlapped each other and were engaging in a battle for dominance during this period on the northern Plains. Greiser (1994) further develops this concept by proposing that Besant populations, likely originating in the Middle Missouri region, controlled the majority of the northern Plains from roughly 1300 to 1500 B.P. Reduced bison populations resulting from the Scandic climatic episode favored the advanced technology of the bow and arrow of the Avonlea people, who with this advantage flourished and out competed the Besant populations.

Old Women's

The Old Women's phase occurs from 1,200 to 400 B.P., within the Late Prehistoric and Protohistoric designation (Morlan 1988). Projectile points recognized from this complex have been labeled Prairie and Plains side-notched, the latter being ascribed to Avonlea people and the former attributed to Besant (Kehoe 1966; Morlan 1988). Frison also describes a variant on the more traditional design as "base-notched" or "tri-notched" (Frison 1991). Old Women's phase ceramics have been linked by Keyser and Davis (1981) to Middle Missouri villagers. Old Women's Jump and Head-Smashed-In are two of the most prominent sites attributed to this phase. A Plains side-notched projectile point was recovered from the surface near 48BH245 (Prentiss & Light 1993).

Reeves (1990) has alleged that the Old Women's phase represents the zenith of the classic pre-contact large game hunters on the northern Plains. Various debates have arisen over the possible ethnic identity of the Old Women's people. Reeves (1983) considers this phase to be a combination of traits from both Besant (manifested in the Prairie side-notched point) and Avonlea (manifested from the Plains side-notched point). Greiser (1994) challenges this presumption by asserting that these point types occur separately at bison kill sites throughout the region. Greiser believes this to be an indicator of two separate groups competing for a limited resource (bison). Frison (1986 et al.) has noted that archaeologists must consider that the small side-notched arrow points are found extensively throughout the Late Prehistoric Plains and prescribing an ethnic affinity to any one specific group would be exceedingly difficult.

MIDDLE MISSOURI REGION - LATE PREHISTORIC

Researchers view the Middle Missouri region as separate culture area within the Plains region due to the emergence of horticultural-based traditions after 2000 B.P. The early Prehistoric traditions are thought to be the forerunners to the later Protohistoric Mandan, Hidatsa, and Arikara (Schlesier 1994). Geographically, the region is defined by a western border of the Missouri River in North Dakota eastward to the Lake Francis Case area located in south-central South Dakota. Six subregions are included within the Middle Missouri region. They are Big Bend, Knife-Heart, Grand Moreau, Garrison, Cannonball, and Bad Cheyenne. Big Bend will be the primary focus of this discussion since this subregions close geographic proximity to the Fort Pierre National Grasslands area.

The Middle Missouri region has been the focus of numerous archaeological investigations. Several important summaries, chronicling the archaeological histories of this region, have been authored by Lehmer (1971), Tiffany (1983), and Winham and Lueck (1994). Empirical research in this area has shown a complex sequence of cultural development starting circa 200 B.P., unfortunately theoretical considerations as to the evolution of social complexity, trade systems and the rise of horticulture have been late to arrive (Tiffany 1983; Anderson 1987; Blakeslee 1993, Lensink 1993; Toom 1990, 1992). Localized raw material sources (Knife River flint and Bijou quartzite) were readily available and exploited by regional populations. It is also noted that Madison formation cherts from the Rocky Mountains were also being imported into the Middle Missouri and upper Midwest as early as Hopewell times (Boszhardt 1998). Therefore, it is reasonable to conclude that the growing populations of the Late Archaic and Late Prehistoric may have produced an elevated demand for high quality lithic raw materials which in turn would have an effect of quarrying strategies and rates on the northwest Plains.

The ensuing outline will focus on the central chronological traditions, artifact and feature assemblages and radiocarbon dates from the Middle Missouri period. A brief overview of theoretical debates concerning the interrelationships will also be presented. These debates have centered around the evolution of subsistence and settlement strategies (Anderson 1987), the historical relationships the cultures of the Plains Woodland and later village phases (Lehmer 1971), and finally the ethnic group formation, migration and geneses of Protohistoric tribes of the Mandan, Hidatsa, Arikara, and Cheyenne (Wood 1967; Winham & Lueck 1994; Schlesier 1994).

Plains Woodland Pattern

The cultural complexes and stylistic traditions of the Plains Woodland tradition are relatively understood due to geographic and temporal variations. The ensuing discourse profiles the fundamental complexes of the Plains Woodland traditions. The most notable innovations from the earlier Archaic period consist of ceramics, earthen occupational structures, storage pits, and diets augmented by horticultural activities.

Besant-Sonota

As previously outlined, the Besant complex is linked by researchers to the Sonota Complex of northern and central South Dakota (Neuman 1975). This relationship has been established through correlations between burial mounds, side-notched projectile points, cor-marked pottery and the intensive exploitation of bison. Besant-Sonota sites in northern South Dakota date from 2000-1400 B.P. as seen in Arapan Mound, Swift Bird, Stelzer, and Grover Hand. Important sites from central South Dakota include 39ST80 and 39ST9 (Winham & Lueck 1994:153). Based on abundant amounts of bison bone, in relation to other floral or faunal remains recovered from Sonota sites, researchers have assumed an intense reliance on bison as a dietary resource, and relatively low reliance on horticulture as a dietary supplement.

Linkage between the Besant-Sonota and Protohistoric tribes remains cloudy. Schlesier (1994) proposes the Sonota to be the ancestor of the Protohistoric Cheyenne while the Besant are the precursors to the Blackfeet, both with origins farther to the east in the Upper Mississippi Valley region. Greiser (1994) agrees with this assumption. This debate is still uncertain and needs further theoretical work concerning the relationship between the

diffusion and variation of technological and stylistic traditions (cf. Neiman 1995) and the process of cultural evolution (cf. Boyd & Richerson 1985).

Valley Phase

The Valley Phase is contemporary with Besant-Sonota (Winham & Lueck 1994:153). Geographically, Valley phase sites are located in south-central South Dakota near the Missouri River trench and in north-central Nebraska. Significant sites from the South Dakota area include from this area include La Roche (component D), Ellis Creek Village, Arp, Scalp Creek, Hitchell, and Good Soldier (Winham & Lueck 1994:153).

Loseke Creek Phase

The Loseke Creek phase, dating from 1400 to 1200 B.P., is also found near the Missouri River in southern South Dakota. Notable sites from this phase would include, Arp, Ellis Creek Village, Wheeler Bridge Mound, Woodland Village, Old Quarry Mound, Hitchell, Side Hill Mound, and Scalp Creek (Winham & Lueck 1994:153). Lithic raw materials represented at these sites are dominated by Bijou Hills quartzite.

PLAINS VILLAGE PATTERN

Winham and Lueck (1994) propose that the Loseke Creek phase gave rise to the Middle Missouri villages in south-central and central South Dakota. Toom (1992) assigns a date of approximately 1000 B.P. for the start of the Initial Middle Missouri tradition and the Plains Village Pattern. The Initial Middle Missouri is bisected by Toom (1992) into an

eastern and western division and further dissected into the subdivisions of Cambria, Mill Creek, Great Oasis and Over phases in the eastern portion and Grand Detour, Swanson and Anderson phases in the western portion. The next sections will outline the generally accepted sequence to the Middle Missouri chronologies. Material culture, and theories concerning population migrations and evolution will also be highlighted as well as dates as they pertain to the Initial Middle Missouri, Initial Coalescent, etc.

Great Oasis Phase or Aspect

While Toom (1992) regards Great Oasis to be part of the eastern subdivision of the Initial Middle Missouri Tradition, Winham and Lueck (1994) assert that Great Oasis should be recognized as a transition period between Woodland and the Initial Middle Missouri from the Missouri River Trench area. Great Oasis has been ascribed the dates of 1200 to 800 B.P. Important sites are 39LM59, 39LM66, Good Soldier, Pease Creek Village, Bengé Creek, Oldham Village, Arp, and Hitchell (Winham & Lueck 1994:159). Debate has arisen over the chronological relation of Great Oasis to Initial Middle Missouri. Both Alex (1981) and Tiffany (1983) consider Great Oasis to predate and be contemporaneous with the Initial Middle Missouri. Toom (1992) suggests an alternate theory that Great Oasis sites, with their mixture of Woodland and Plains Village traits, are some representations of fragmented populations influenced by the population influx from the east by Plains Village inhabitants.

Initial Middle Missouri

Dates from the Initial Middle Missouri range from an emergence at around 1000 B.P.

to a termination at roughly 700 B.P. (Toom 1992). This tradition is recognized as being located along the Missouri River between the Fort Randall Dam and the Cheyenne River (Winham & Lueck 1994). Significant Initial Middle Missouri sites, in proximity to the Fort Pierre National Grasslands are numerous. Various research has indicated that subsistence strategies center on upland bison hunting with an additional reliance on horticulture and the exploitation of floodplain fauna (Ludwickson, Blakelee & O'Shea 1981; Winham & Lueck 1994). Stone tools consist of small triangular and side notched points, drills, groundstone (celts, grooved axes and mauls, and shaft smoothers) (Lehmer 1971). Small Initial Middle Missouri sites have been recorded in the White River Badlands, the Black Hills and in northwestern South Dakota. Johnson links these sites to possible seasonal patterns of mobility connected to episodes of resource and lithic procurement.

Various models have been offered by researchers to explain the expansion of Initial Middle Missouri populations. Perhaps one of the most feasible explanations for Initial Middle Missouri expansion is due to pressures placed on these communities from population expansions from the east by Mississippian peoples (Toom 1992; Bamforth 1993).

Extended Middle Missouri

The boundaries of the Extended Middle Missouri (EMM) tradition has been defined as Lake Sharpe in central South Dakota in the south, extending north to the Knife River. Dates from the EMM span from 1000 B.P. to around 500 B.P., making it contemporaneous with the Initial Middle Missouri tradition (Winham & Lueck 1994). Important sites consist of 39ST203, 39ST39, Indian Creek Village, Durkin Village, Black Widow, Hallam II Village,

Cattle Oiler Village, Breeden's Village, and Ketchen Village (Winham & Lueck 1994:167). Wood (1967) and Tiffany (1983) have subdivided the Extended Middle Missouri tradition into a northern (Fort Yates Phase) division, linked to the Hidatsa, and southern (Thomas Riggs focus) division associated with the Protohistoric Mandan.

Coalescent and Terminal Middle Missouri Traditions

The Initial and Extended Coalescent traditions have been associated with Caddoan migrations moving into the Middle Missouri region (Strong 1933,1935; Lehmer 1971; Willey & Emerson 1993; Winham & Lueck 1994). Research into the Coalescent has been focused on demonstrating the Protohistoric movements and origins of the Mandan, Arikara, Pawnee, and Cheyenne peoples and identifying any possible cultural affiliation between these groups and the people of the Coalescent traditions (Strong 1940; Deetz 1965; Lehmer 1971; Wood 1971; Blakeslee 1981; Schlesier 1988). Exploration into the Coalescent traditions has also been concerned with Caddoan population movements from the south (Blakeslee 1993) and prehistoric warfare, as seen at the Crow Creek Massacre site, within the Middle Missouri area (Willey 1990; Willey & Emerson 1993; Zimmerman & Bradley 1993).

Dates from the Initial Coalescent (IC) are ascribed between 700 and 500 B.P. Initial Coalescent components have been identified as being concentrated around the Lake Sharpe area of central South Dakota (Winham & Lueck 1994:170). Significant sites are numerous, examples would include; Crow Creek, Scalp Creek, Granny Two Hearts, De Grey Village, Denny, Talking Crow, Useful Heart/Over Camel's Creek, Earthlodge Village, Whistling Elk Village, West Bend, Arzberger Village, Farm School, Medicine Creek Village, Black Partizan

Village, and Sharpe/Oacoma Village II (Winham & Lueck 1994). Subsequent artifacts identified in Initial Coalescent sites consist of grooved mauls, horn scoops, bison skull hoes, scapula hoes, tobacco pipes, and diamond shaped knives with beveled edges (Lehmer 1971).

The Terminal Middle Missouri is considered to be derived from the earlier Initial and Extended Middle Missouri populations that moved north from central South Dakota and settling between Lakes Sakakawea and Oahe (Winham & Lueck 1994:170). Eminent sites from the Terminal Middle Missouri are 39CO1, 39CO212, 39DW231, White Bull, and Helb (Winham & Lueck 1994:173).

Coalescent origins are generally perceived as resulting from population movements out of the south. Traditionally, these debates have attributed xerification of environments as the catalyst behind the abandonment of whole regions within the Central Plains (Lehmer 1971; Wedel 1986). The influx of populations into the Middle Missouri region is generally accepted, regardless of the catalyst for this movement of people.

SUMMARY

The archaeological record from the northern and northwest Plains has shown researchers a shift occurring in the subsistence strategies of the prehistoric inhabitants, starting in the Paleoindian period and culminating in the Archaic period. Within the Paleoindian period (11,500 to 9,500 B.P.) Clovis, Goshen, Folsom, Agate Basin, Hell Gap, Alberta, Alberta-Cody and Cody Complexes, faunal resource procurement strategies were focused around big game hunting. A shift towards broad spectrum foraging, occurring in the

latter stages of the Cody complex and continued up through the Early Archaic, has been observed through an increasing diversity in technologies and land use patterns. The expansion of site components at this time has also been noted as an indicator for increasing populations. Projectile points rapidly diversify after 8000 B.P. from the traditional lanceolate stemmed points of the Paleoindian period to the classic notched forms characteristic of the Early Archaic. Shifts in cultural adaptations coincide with changes in the environment associated with the culmination of the Pleistocene and the initiation of Holocene warming. Increased moisture levels and improved large game habitats favored the intensification of bison hunting in the Late Archaic. With the amplification of bison hunting, new trade opportunities in the Late Archaic and Late Prehistoric periods were realized. The development of large scale lithic procurement strategies, favoring the establishment of quarry sites like Spanish Diggings and the South Paint Rock Chert Quarries, was now economically feasible.

CHAPTER THREE

Excavations - 1998 Summer Fieldschool

Field Methods, Results, and Analysis

Preliminary archaeological investigations at South Paint Rock Chert Quarries were conducted in fall of 1992 and throughout the summer of 1993 by Frontier Archaeology under the direction of Principal Investigator William C. Prentiss. This project was designed to evaluate two previously identified sites (48BH112 and 48BH245) and determine significance of and impact to these sites by heavy vehicular traffic along and the Battle Park Road in the Bighorn National Forest. This project was also designed to determine the effect of a proposal to modify a portion of the road and install two turnouts near these sites along Battle Park Road.

As a result of the investigations conducted by Frontier Archaeology, seventeen 1x1 m excavation units and sixty 50x50cm test units were excavated within the site boundaries of 48BH112 and 48BH245. Archaeological research goals were centered on the investigating any variability in the sedimentary deposition of the sites and recovering diagnostic artifacts which would aid in the assessment of occupation characteristics. More than 9,300 artifacts were unearthed during the course of investigations at 48BH245. Significant diagnostic artifacts recovered included three projectile points, individually associated with the Early Archaic, Middle Archaic, and the Late Prehistoric periods. A distinctive stratigraphic pattern of lithic reduction indicating biface production in lower levels, and a clear pattern of core

reduction activities in upper levels were noted from units placed along the top knoll and saddle area of 48BH245.

While no quarry pits were excavated during the field season of 1993, the primary focus of the 1998 field school was centered on the excavation of the interiors and berm portions of two of these pits. The goal of this work was to recover any organic material suitable for radiocarbon dating of these features and to identify quarry pit stratigraphy and formational processes which could possibly provide insight as to behavioral patterns involved in prehistoric quarrying. Excavations were conducted utilizing natural and arbitrary levels. Soils were screened through 1/8 inch mesh. Point provenience maps were drawn to record any features or artifacts, as well as any concentrations of natural rock, within the test units. Contour and plan view maps were also drawn for each level in the excavation units. Preliminary analysis of collected materials was conducted within the laboratory facilities located at the University of Montana. Analyses included lithic assemblage, faunal, soils, and radiocarbon dating.

The subsequent sections of this chapter will outline field methods, results and analyses undertaken as a result of the 1998 University of Montana investigations at South Paint Rock Chert Quarries.

Field Methods

The 1998 archaeological investigations and excavations at south Paint Rock Chert Quarries (SPRCQ) were arranged using a conventional grid system based on one meter increments. The fixed site datum was established by Light and Prentiss (1993) during

previous investigations at SPRCQ. This datum was placed in a centralized position at a largely visible point southwest of the proposed excavation areas for this project (see Map #1). A horizontal designation of 0 north/0 east and a vertical designation of 0 meters was assigned to the permanent site datum. All horizontal proveniences were expressed as meters north and east of the site datum. Excavation units were labeled from temporary datums established in their northeast corners. Vertical proveniences were determined metrically in respect to an arbitrary designation of 0 meter point, and depths or elevations were measured from this point. Mapping of the site and excavation units was accomplished using a transit, stadia rod and metric tape.

Excavation units were laid out in 1x2 meter squares. When circumstances warranted, 50x50 centimeter and 1m x 50cm sub-squares were excavated within the units. Natural stratigraphy, utilizing a stratum I, II III . . . x system, determined vertical controls during excavation. When stratigraphic differences were not evident, excavation advanced in arbitrary five centimeter levels. Excavation of the units was completed with trowels. In the event of unstable materials, excavation utilized small bamboo picks and spoons. With the exception of special samples, soils were screened through 1/8 inch mesh.

Level forms were filled out at the completion of every arbitrary or natural excavation level. This form summarized sediment coloration, artifact distributions, sediment disturbances (bioturbation), sediment composition (using the Wentworth Scale for percentage of sediment particle composition), and points of contrasting sediment types. Photographs were taken of each unit prior to the excavation of the units and after the completion of each level. Profile maps were drawn from two walls of the excavation units depicting soil types and colors as

well as highlighting any objects intruding through unit walls (rock, roots, rodent burrows). Plan view maps were also drawn at the termination of excavations for each level. Soil color designations were taken from dry sediments by a single recorder using a Munsell color chart.

Features

Any features that were uncovered within the test units during the course of excavation were exposed horizontally and plan views were drawn to illustrate the size and location of any artifacts or other materials within the feature. Photographs were taken of features prior to excavation and upon completion of excavation. Features were excavated by cross-sections oriented along the long axis in natural excavation levels or arbitrary 10cm levels where necessary. This allowed excavators to remove half of the fill at a time to facilitate the collection of flotation and soil samples from the feature. Upon completion of cross-section feature excavation, stratigraphic profile maps were drawn of the remaining fill in order to determine if internal stratification was present within the feature fill.

A vertical walled pit (feature 1) was found directly under Stratum I in the southwest corner of Excavation Unit 18N-31E. High phosphorus levels from this feature indicate that the feature could be the result human activity or deliberate modification.

Artifacts

Cultural materials recovered during the course of excavations were bagged separately according to level and stratum. To maintain stratigraphic relationships, all in-situ artifacts and flakes over three cm² were recorded on point provenience maps and given a field specimen

or ancillary provenience number and bagged individually. In-situ artifacts were also recorded in a daily Field Specimen Record. Bags containing artifacts were labeled with site designation, unit identification, level and stratum information, the identity of the excavator(s), and the date of excavation. In addition, all bags were assigned an ascending number based on the order they were recorded in the daily Field Specimen Record.

Special Samples

Systematic samples were taken from each excavation unit, and cultural feature where warranted. These samples were collected to facilitate the analysis of site activities and environment. Each sample was given a separate ancillary number and recorded at the end of a field day in the Field Specimen Record.

A minimal amount of faunal and microbotanical remains were collected from the excavation units. The provenience information placed on bags containing faunal remains followed the previously discussed procedures use for artifacts.

Sediment samples, representing cultural and natural levels, were collected to interpretate stratigraphic relationships and structure. For each stratigraphic layer within the excavation units, approximately 200 ml of sediments were collected per sample. Soil samples were also collected for flotation purposes and to support field descriptions from sediment color to structure.

No charcoal samples were recovered during excavations, although one bone tool was retrieved and used to establish a radiometric date for Quarry pit #4 (QP4). This tool and its significance will be discussed in forthcoming sections.

FIELDWORK

The University of Montana Summer Archaeological Field School commenced excavations at the South Paint Rock Chert Quarries, specifically 48BH245, on Tuesday the 23rd of June. Upon arriving on site, staff and students conducted an initial reconnaissance of the site area. After pinpointing and reestablishing the permanent site datum, excavation units were aligned and laid out. Five units were placed in proximity to two quarry pits (QP#4 and QP#7: see Light & Prentiss 1993). The three 1x2 meter units excavated in associated with QP#4 were placed on the southern pit berm (18N-31E), on the northern interior (24N-31E), and on the northern exterior (27N-31E) of the quarry pit (Figure #2). Two additional units (75N-39E and 83N-38E) were placed on the southern and northern berm of QP#7 respectively (Map #3).

Field crew members consisted of Principal Investigator: William Prentiss; Assistant Field Director: Kyle Wright; Field School Students: Terry Godin, Michael Warren, and Matthew Cleveland; Volunteers: Thecla Backhouse-Prentiss, Patrick Light, Sherryl, Breece, Kelly, Elizabeth, Denise and Allan Ferguson, and Michael McGinley. Field operations were concluded on the 4th of July 1998. Due to time constraints, all of the units were not excavated to bedrock. As the project end date approached, a sub-sampling approach was used to expedite excavation of the units to their full potential. Test units were subdivided into quadrants and partially excavated to provide a sample of materials and stratigraphy in lower levels which were unlikely to be unearthed completely due to time constraints. This process will be discussed in the individual descriptions of the units. Evidence discussed in the subsequent sections is the results of field data collection as well as laboratory analyses

conducted at the University of Montana's laboratory facilities. Specific results ascertained from lab analysis will be further elaborated on in their respective sections of this chapter. The quantitative figures collected during the initial stages of analysis of the lithic materials recovered during the 1998 excavations at 48BH245 will be discussed in subsequent sections of Chapter Three. A more in-depth discussion of the analytical methods utilized in the investigation of these collections will be detailed in Chapter Four.

Excavation Units: Quarry Pit #4

18 North - 31 East

This unit was set on the southern berm of QP #4 and excavated to a maximum depth of thirty-seven centimeters below the surface. Three natural strata were exposed during the course of excavation (Figures 3-5; Table 1). Stratum I was composed of a very dark grayish brown clay loam. A large percent of pebble to cobble size limestone fragments (roughly 30% of total matrix) was noted in level forms. Depths from Stratum I varied from 10cm to 15cm. A vertical walled pit (feature 1) was found directly under Stratum I in the southwest corner of this excavation unit (for details see Stratum IV and Features sections). Phosphorus levels tested exceptionally high in this stratum in comparison to succeeding levels. Stratum II was excavated in a 50cm by 1m sub-square placed in the northeast corner of the unit. Two distinctive levels were noted in Stratum II. The first (level 1) consisted of a dark grayish brown loam with high concentrations of pebble sized limestone fragments (estimated at 25%

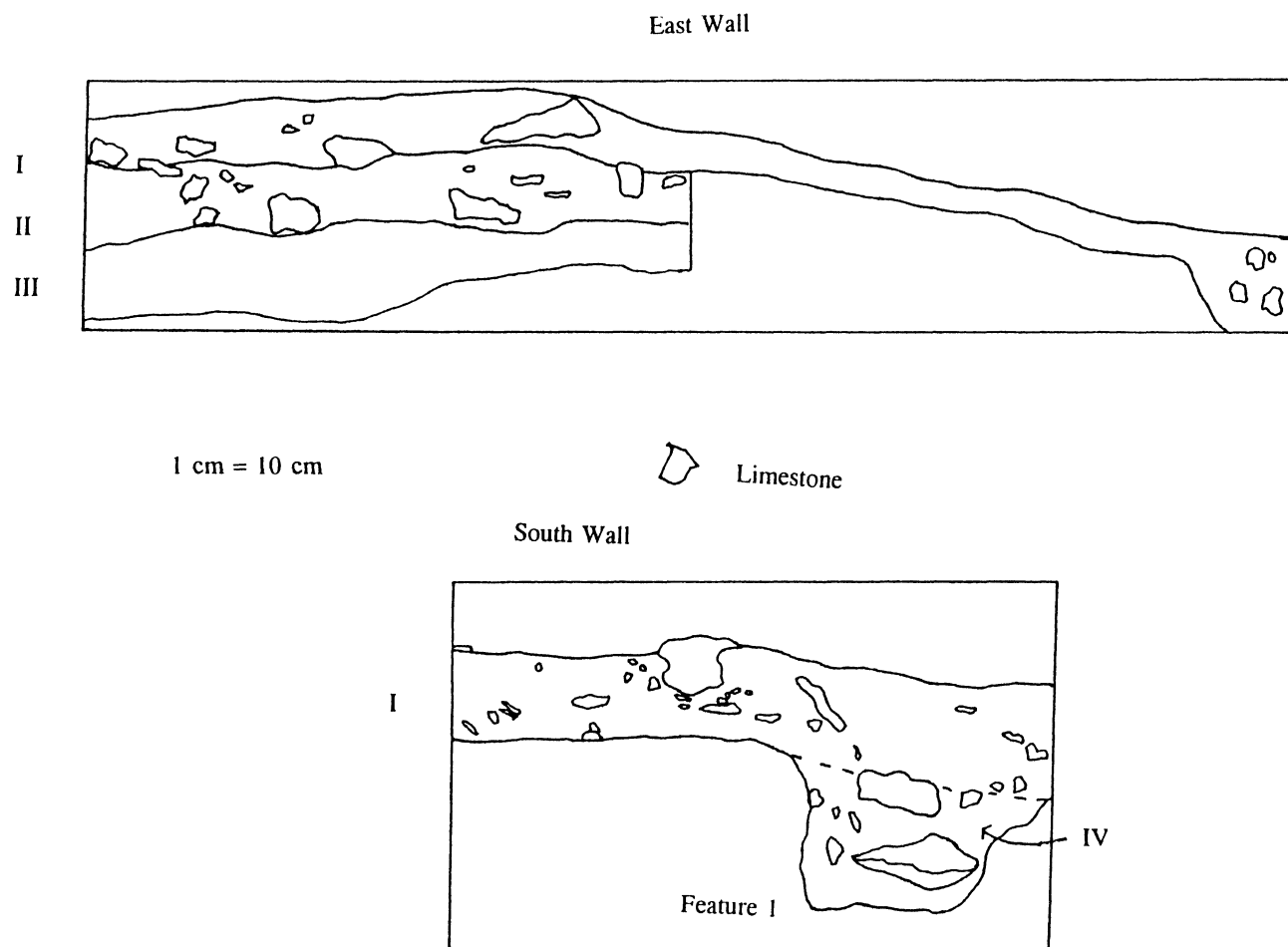


Figure 3. 18N-31E Wall Profiles

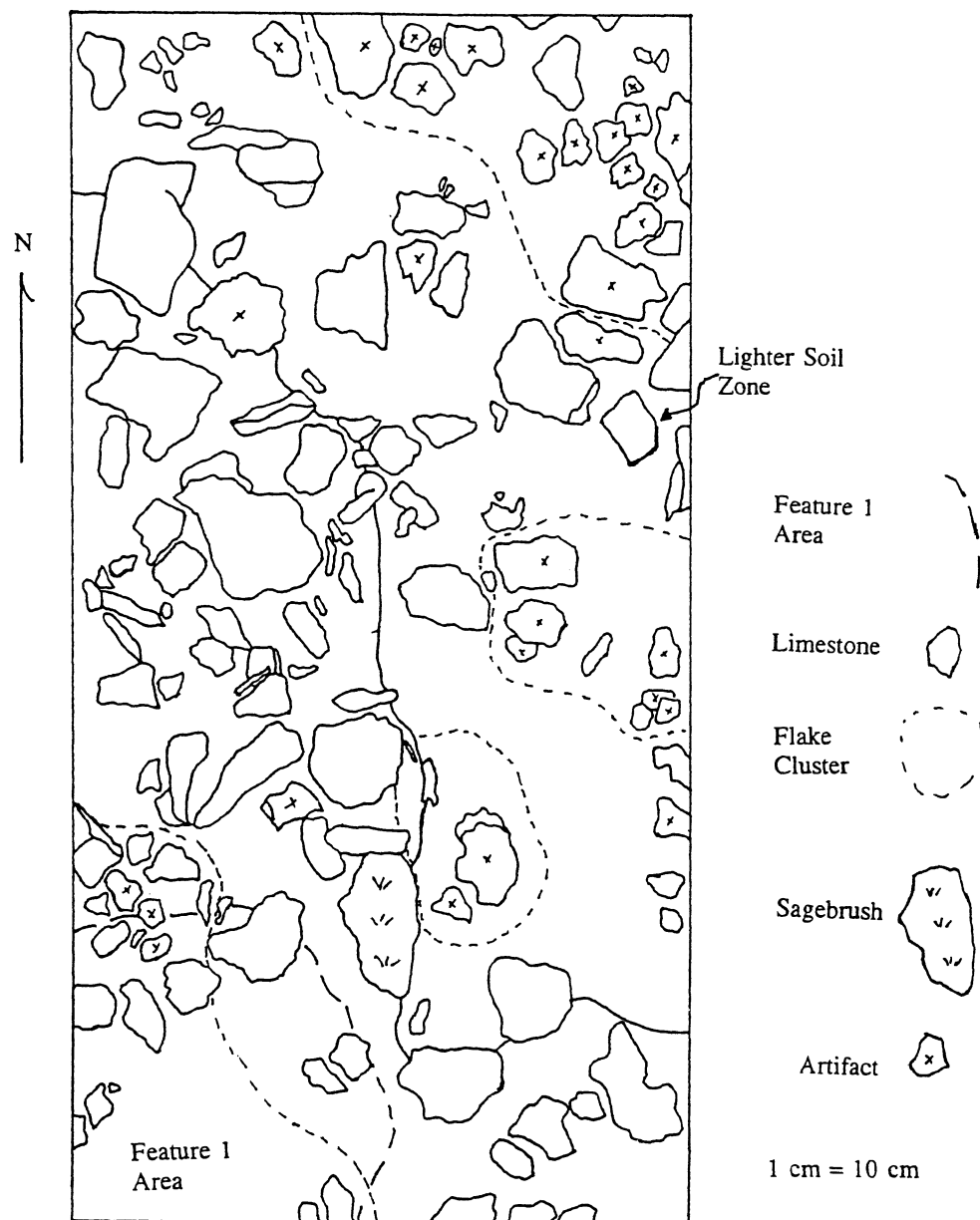


Figure 4. 18N-31E Base of Level 1/Stratum I plan view.

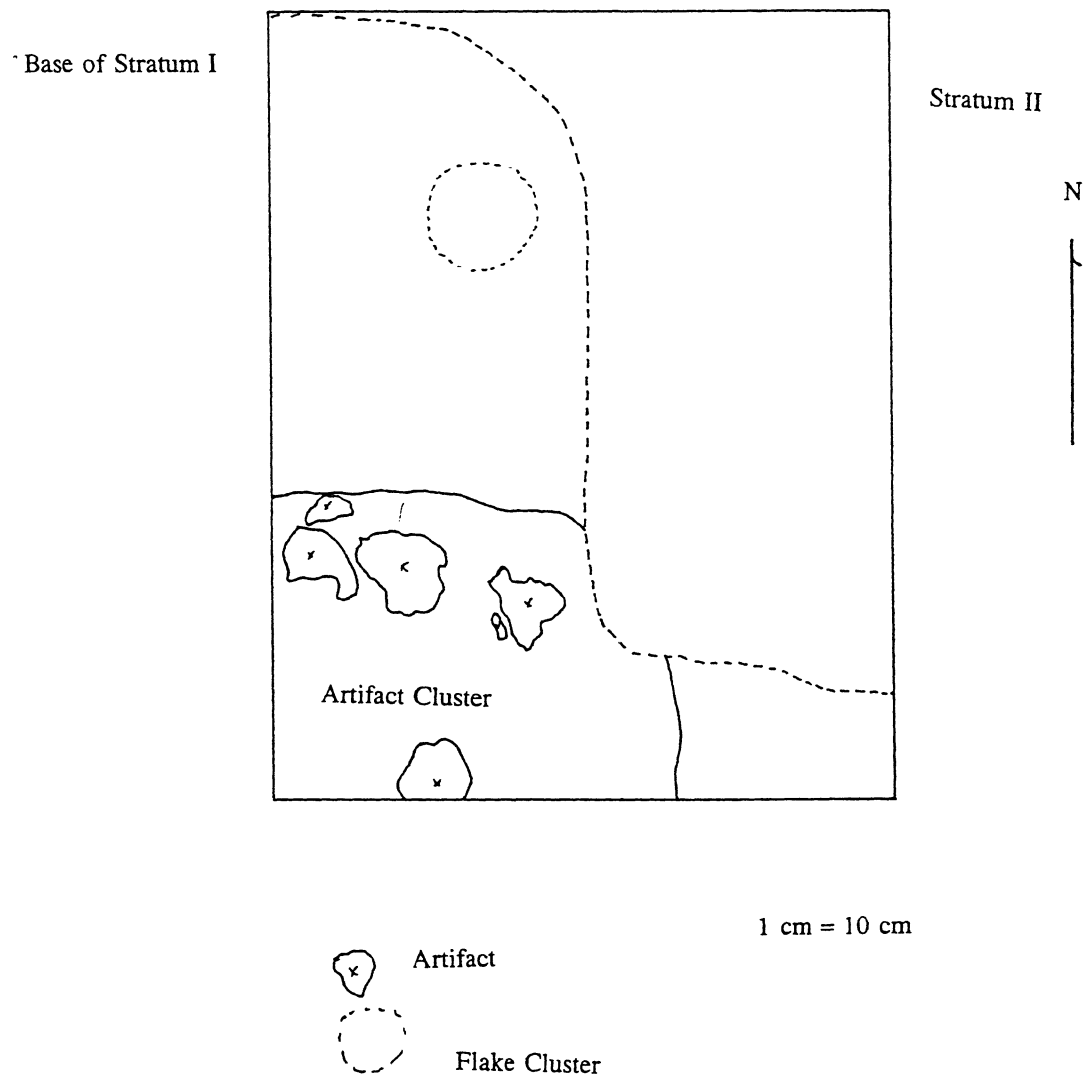


Figure 5. 18N-31E Base of Stratum I in NE Quadrant

of total matrix). Level 2 graded into a light yellowish brown loam with a continuation of pebble sized limestone fragments (20% of total matrix). Stratum III field classifications were altered after an assessment of quantitative data on sediment texture. Originally, Stratum III was defined as occurring in the northeast 50 x 50cm sub-square (or northern half of the 1m x 50cm excavation sub-square). Stratum III was also originally classified as the fill from Feature 1 on the southwest side of the unit. As a result of the sediment texture data, a new stratum was identified and designated as the probable fill from the pit feature. Stratum III was only detected in the lower sediments of the northeast corner of the unit. Stratum III is composed of a dark grayish brown loam with similar levels of pebble sized limestone fragments as noted in the previous two strata (approx. 25%). Stratum IV is the fill associated with Feature 1 and is composed of a brown to grayish brown sandy loam with continuing amounts of pebble sized limestone fragments (20-25% of total matrix).

Table 1. Sediment characteristics of unit 18N-31E

Stratum	Level	Color	% Sand	% Silt	% Clay	P¹	P²
I	1	2.5 Y 3/2	30	38	32	3969.16	52.63
II	1	2.5 Y 4/2	24	30	46	4746.98	13.01
II	2	2.5 Y 6/4	20	30	50	5368.35	6.53
III	1	2.5 Y 4/2	24	43	33	2651.53	3.37
IV	1	2.5 Y 5/2	48	44	8	2225.70	
IV	2up	2.5 Y 5/2	48	46	6	2171.99	4.67
IV	2low	10 YR 5/3	48	48	4	3135.75	4.81

¹ Total Phosphorus

² Extractable Phosphorus

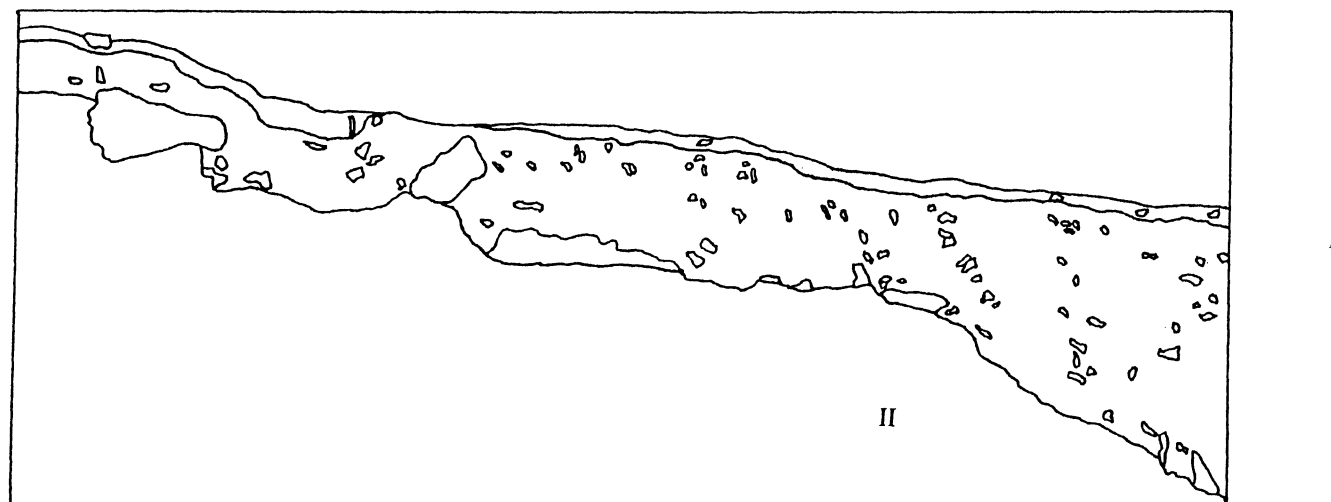
24North - 31East

This unit, established on the northern interior bank of QP #4, was excavated to a maximum depth of 48cm below the surface (Figures 6-9). Within this unit, two distinct soil strata were identified (Table 2). Stratum I extended throughout the unit, almost for the entire depth. This stratum was a very dark grayish brown, silty clay loam. Cobble to pebble size limestone fragments were dense fluctuating between 30 and 50% of the total matrix. In the north end of this unit Stratum I proved to be very shallow reaching a depth of 10cm below surface. Stratum I in the southern half of the unit was much deeper, extending to a maximum depth of 48cm below surface. As depths increased, the spatial extent of Stratum I was reduced and culminated in level five (southern third of the unit).

Table 2. Sediment characteristics of unit 24N-31E

Stratum	Level	Color	% Sand	% Silt	% Clay	P¹	P²
I	1	10 YR 3/3	18	48	34		6.93
I	2	2.5 Y 3/2	16	46	38	1889.79	18.31
I	3	10 YR 3/2	18	50	32	1651.04	8.98
I	4	10 YR 3/3	14	48	38	1708.03	4.38
I	5	10 YR 3/3	16	48	36	1530.08	3.80
II	1	2.5 Y 4/2	12	50	38	1326.64	5.10
II	2	2.5 Y 5/4	16	44	40	1667.40	4.38

¹ Total Phosphorus² Extractable Phosphorus

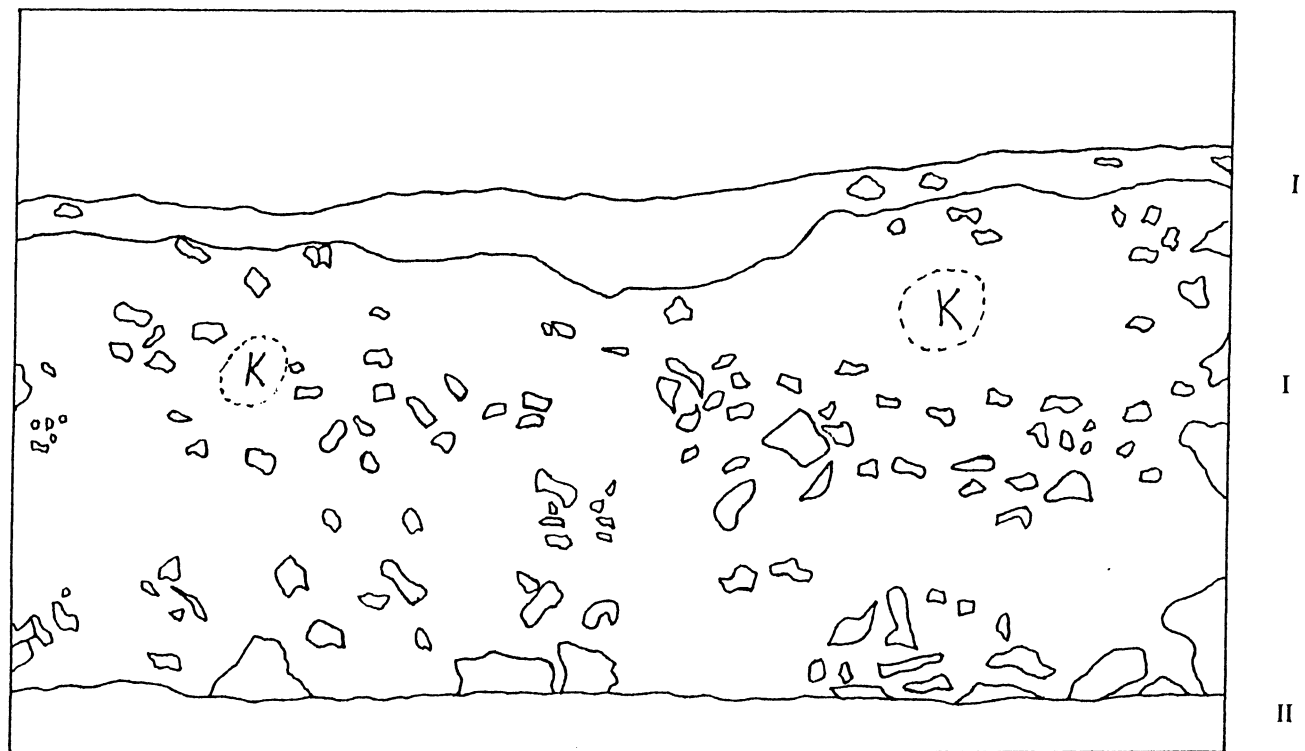


1 cm = 10 cm

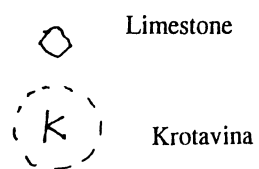


Limestone

Figure 6. 24N-31E East Wall Profile.



1 cm = 10 cm



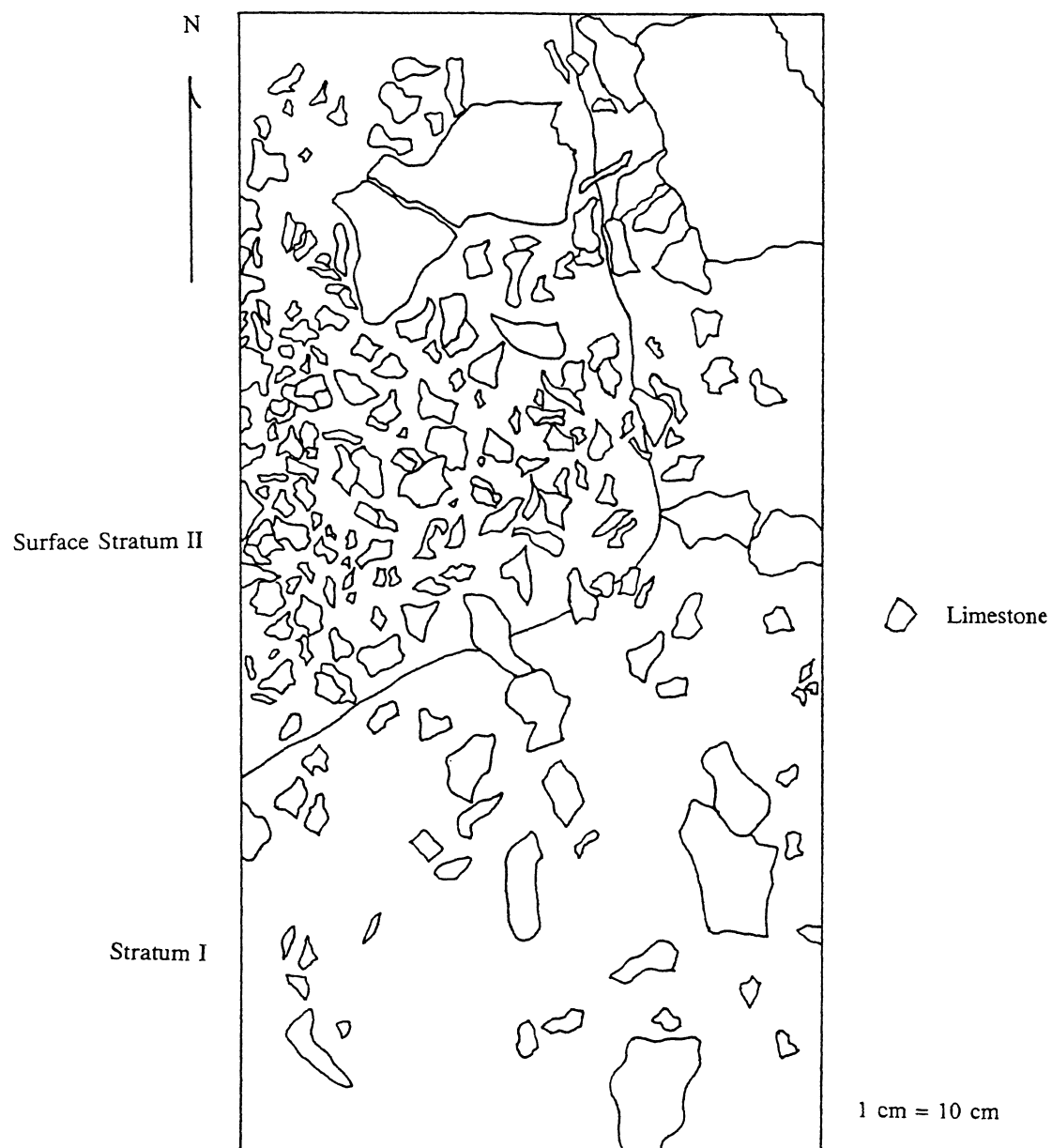


Figure 8. 24N-31E Level 2/Stratum I plan view.

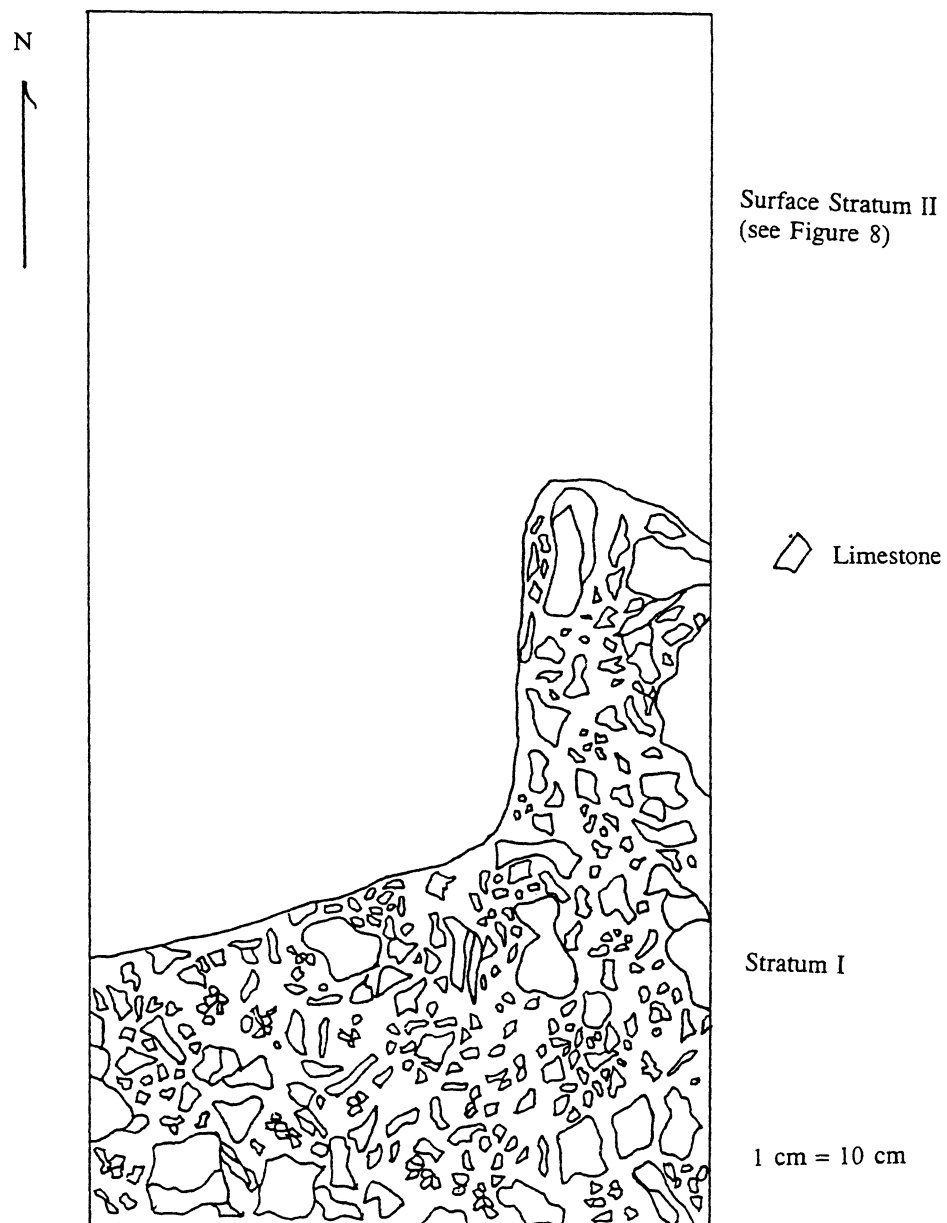


Figure 9. 24N-31E Level 5/Stratum I plan view.

The surface of Stratum II was uncovered at the base of Stratum I. Due to time constraints, a 50 x 50cm sub-square was set on the southern side of the northwest quadrant of the unit. Sediments from Stratum II are described as a light olive brown silty clay with large amounts of pebble to boulder sized limestone fragments (40 % of total matrix). A large piece of bedrock or possibly a boulder was exposed in the eastern half of the sub-square. Phosphorus quantities were low throughout all levels in this unit.

27North - 31East

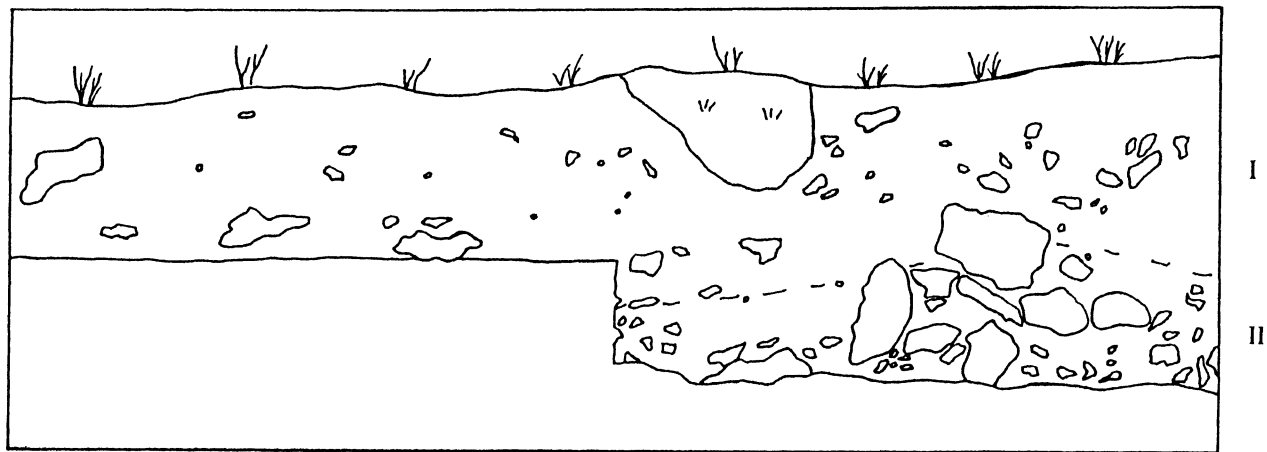
This unit was positioned on the northern exterior of QP #4 in hopes that periphery quarrying activities would be represented in this area (Figures 10-13; Table 3). This unit was excavated to a maximum depth of 55cm below surface. Two separate strata were observed during excavations. The first, Stratum I, was a very dark grayish brown silt loam with low levels of pebble to cobble sized limestone fragments (5-10% of total matrix). Stratum I extended to the base of level 3, after which a 1m x 50cm subsquare was placed in the southwest quadrant of the excavation unit. Stratum I was observed in the subsquare for two more levels (4 and 5). Stratum II was exposed following the fifth level of Stratum I. This strata was described as a very dark grayish brown silty clay loam. An increase in pebble to cobble sized limestone fragments (20-30% of total matrix) was also observed. Wall profiles clearly show this increase in the patterning of limestone rubble indicating that the southern half of the unit could possibly represent sediments derived from quarry pit excavations. Phosphorus levels were recorded as high in Stratum I, level 1 but drop off substantially in the remaining levels of Stratum I and Stratum II.

Table 3. Sediment characteristics of unit 27N-31E.

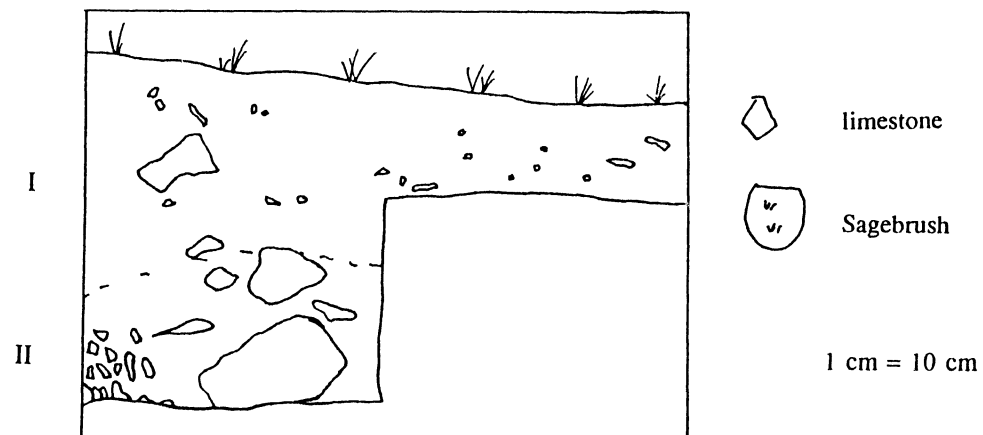
Stratum	Level	Color	% Sand	% Silt	% Clay	P¹	P²
I	1	2.5 Y 3/2	36	40	24	1361.03	26.17
I	2	10 YR 3/2	24	48	28	1199.15	6.39
I	3	10 YR 3/2	26	48	26	1863.55	4.01
II	1	10 YR 3/3	10	54	36	1113.52	3.37
II	2	10 YR 3/2	24	46	30	1573.38	7.54

¹ Total Phosphorus² Extractable Phosphorus

East Wall



South Wall



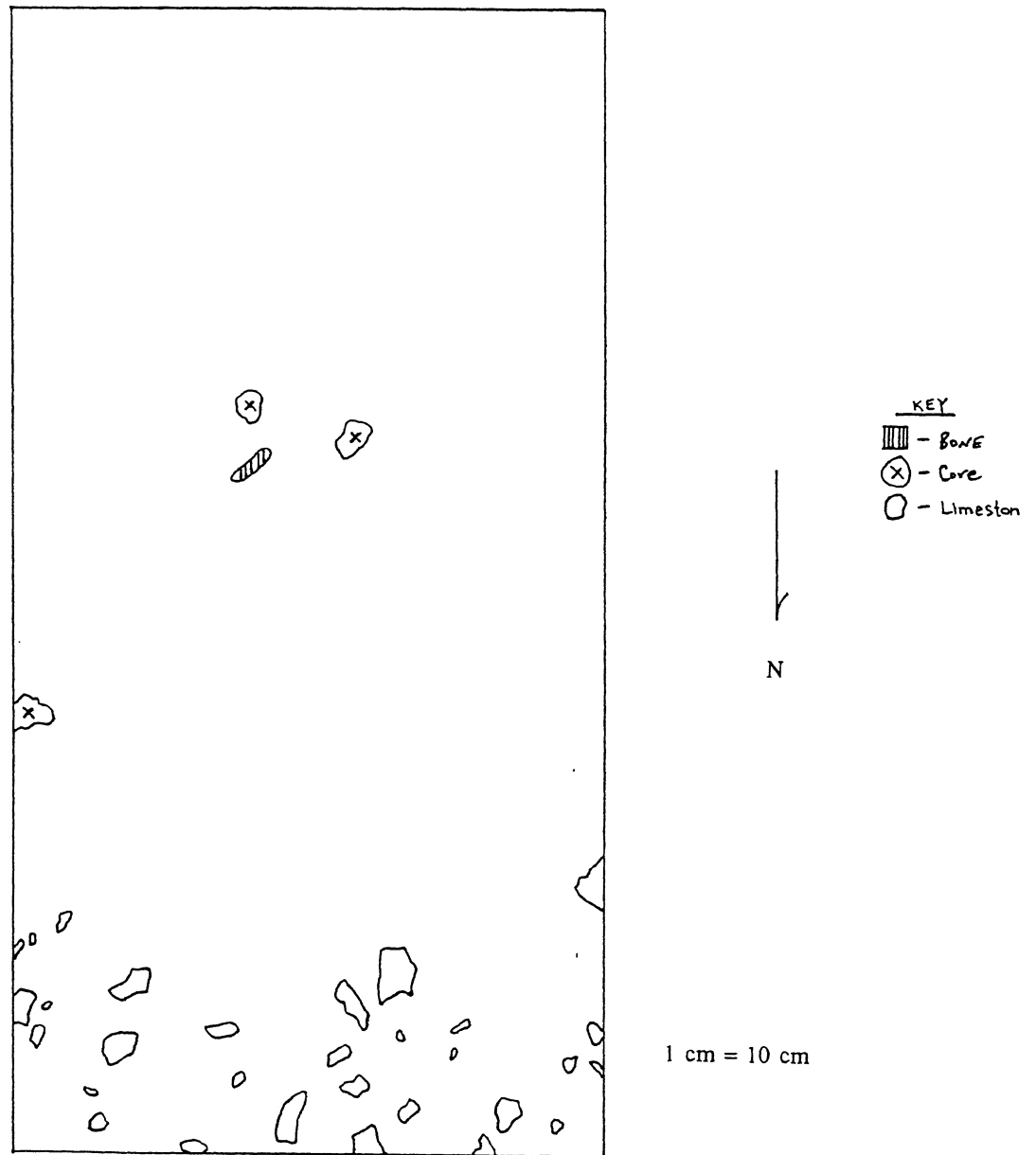


Figure 11. 27N-31E Base of Level 2/Stratum I plan view

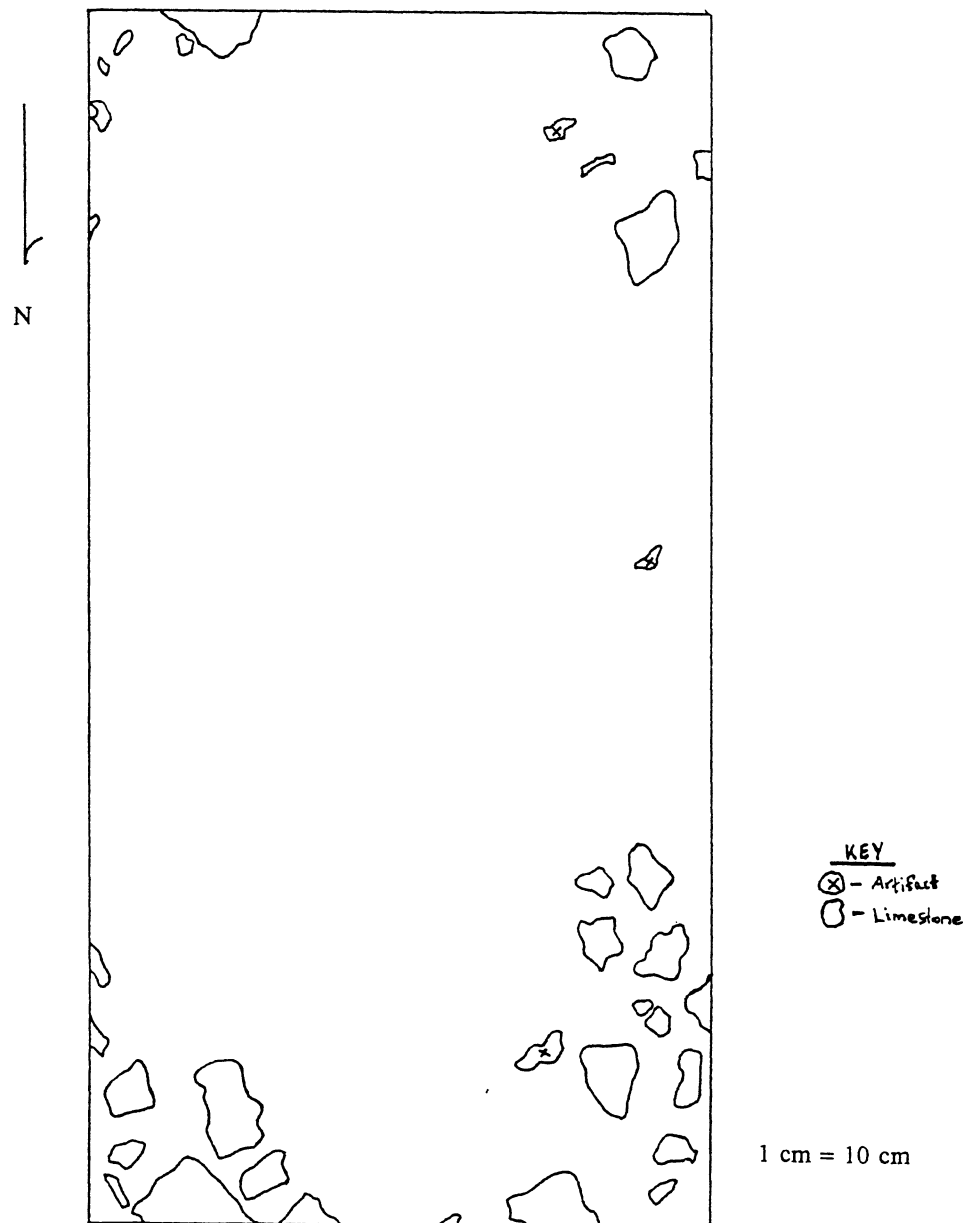


Figure 12. 27N-31E Base of Level 3/Stratum I plan view

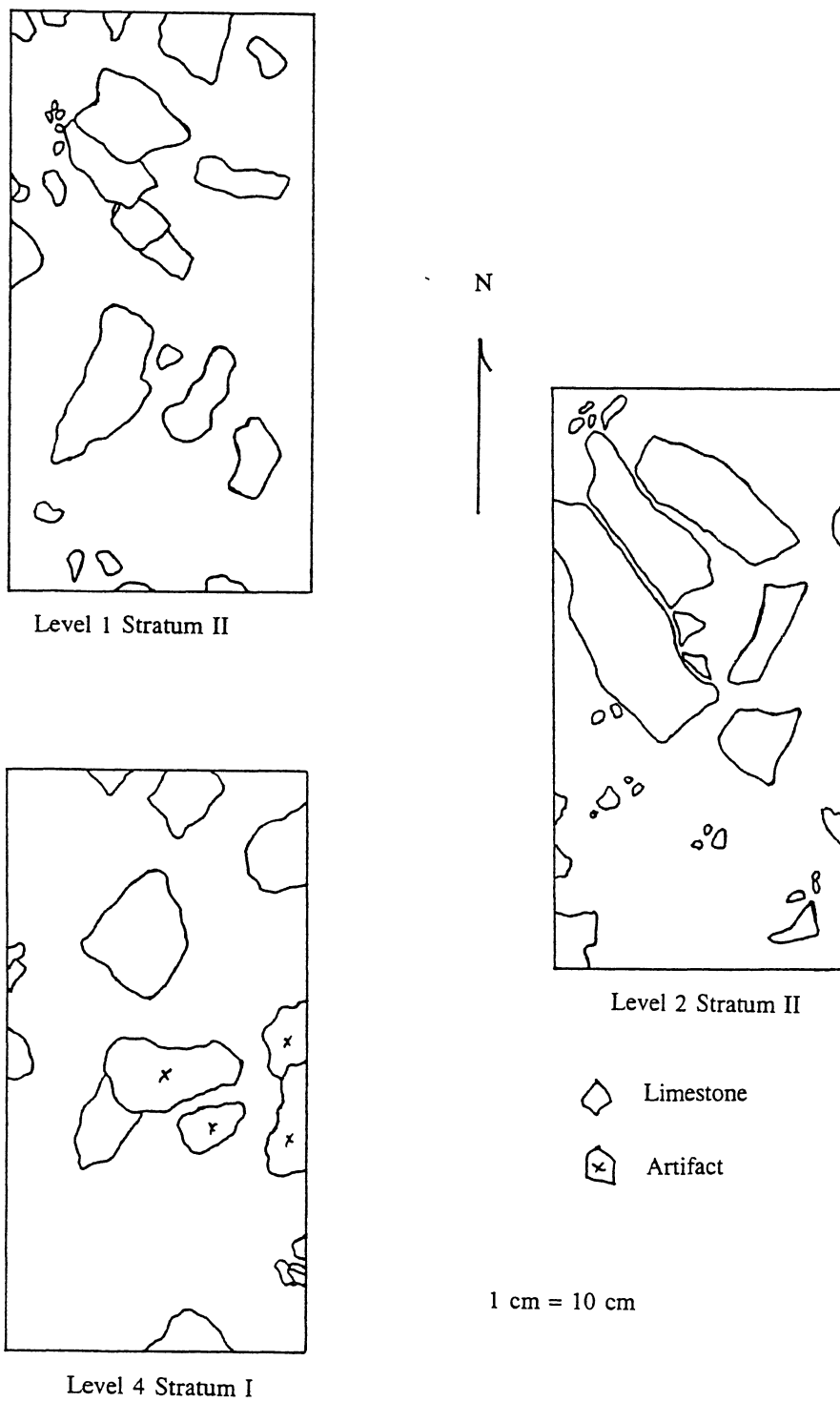


Figure 13. 27N-31E Southeast Quadrant plan views.

Excavation Units: Quarry Pit #7

75North - 39East

This excavation unit was situated on the southern berm of QP #7 and excavated to a maximum depth of 20cm below surface (Figures 14-15; Table 4). Three strata were observed during the course of excavation. Stratum I was recorded as a very dark brown clay loam which ran to a depth of 5cm below surface. Stratum II was classified as a very dark grayish brown clay. High levels of limestone fragments (40-60% of total matrix) in the upper portions of Stratum II were replaced in the lower levels of Stratum II and Stratum III by similar high levels of artifacts. Limestone fragment levels dropped off in the lower portions of Stratum II and into Stratum III significantly (estimated 10-20%) from earlier levels. Stratum III was described as a dark grayish brown clay with extremely high levels of artifacts (approximated at 75% of matrix composed of pebble to cobble sized lithics).

Table 4. Sediment characteristics of unit 75N-39E.

Stratum	Level	Color	% Sand	% Silt	% Clay	P ¹	P ²
I	1	10 YR 2/2	34	38	28	3409.80	50.48
II	1	10 YR 3/2	26	38	36	2869.71	41.90
III	1	2.5 Y 3/2	26	32	42	4232.04	35.47
III	1	10 YR 3/2	24	36	40	3674.18	37.61
III	2	2.5 Y 3/2	20	34	46	4067.36	29.75
III	3	2.5 Y 3/2	24	32	44	3459.35	34.75

¹ Total Phosphorus

² Extractable Phosphorus

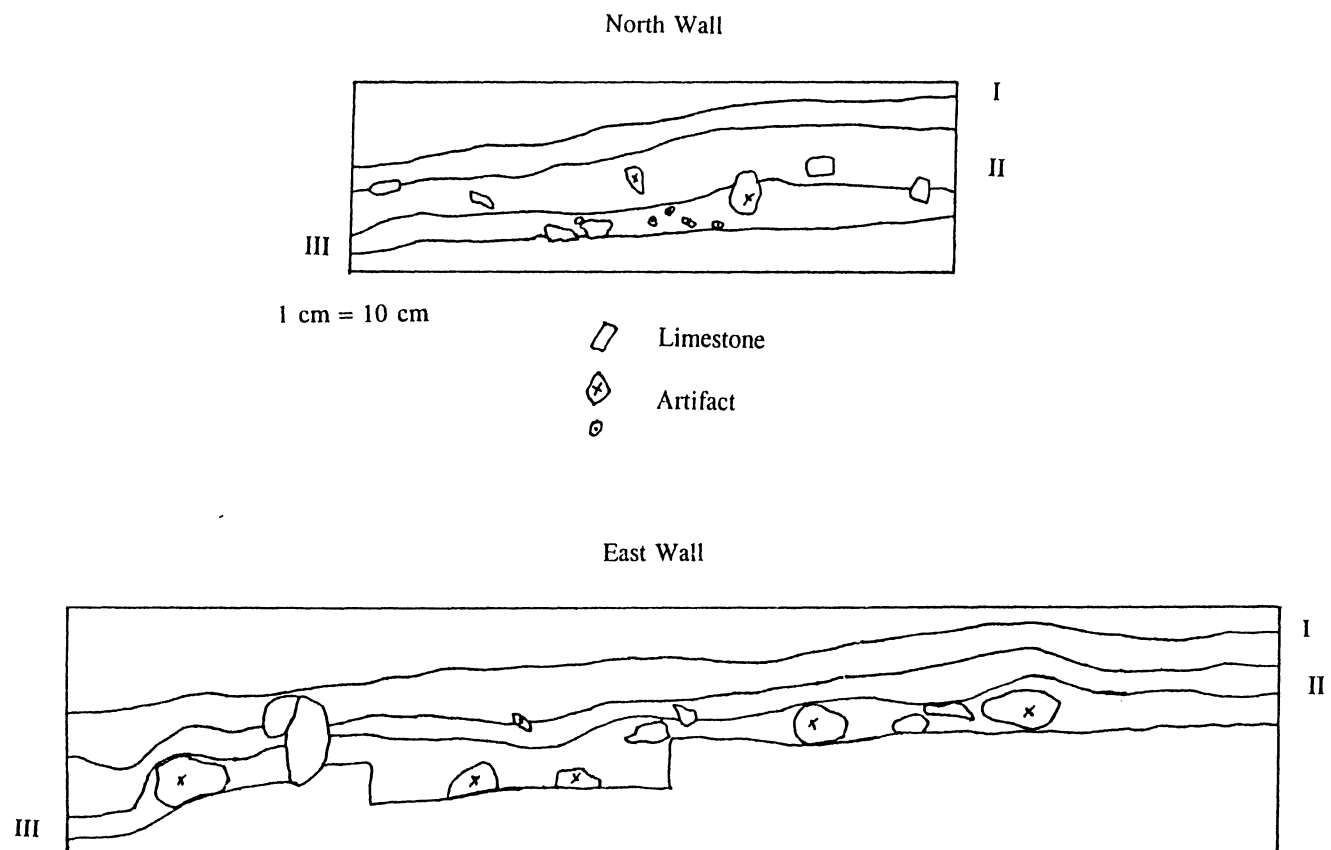


Figure 14. 75N-39E Wall Profiles.

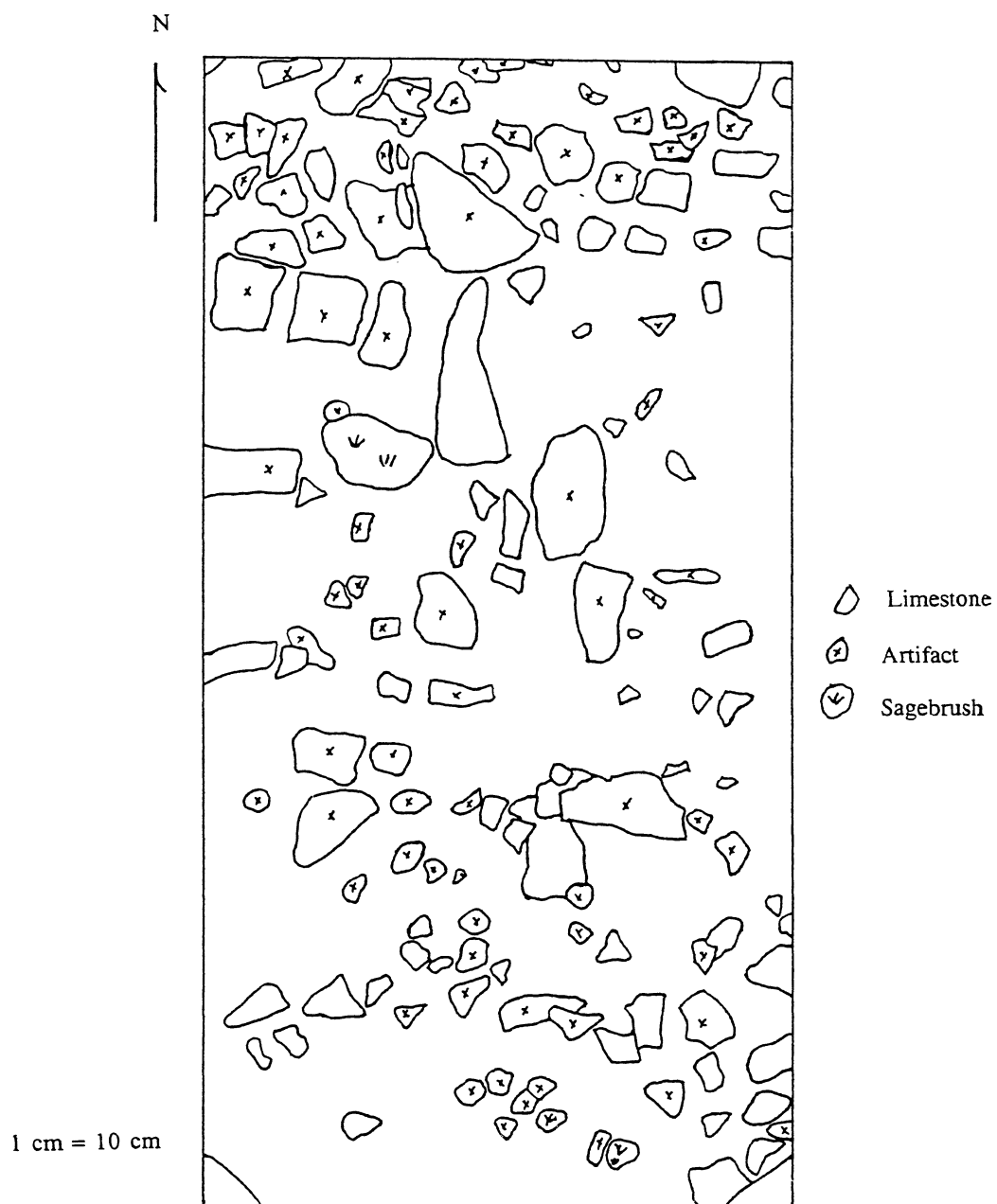


Figure 15. 75N-39E Surface of Level 1/Stratum 3.

Level 1 of Stratum III was exposed throughout the entire unit. Due to time constraints, a 50 x 50cm sub-square was placed in the southern half of the northeast quadrant of the test unit where levels 2 and 3 were excavated. Phosphorus levels were exceedingly high in all levels in 75N-39E.

83North - 38East

This unit was placed on the north side of QP #7. Excavations reached a maximum depth of 18cm below surface (Figure 16-17; Table 5). Two individual strata were recorded from this unit. Stratum I is a very dark brown clay loam with a wide range of pebble, cobble and boulder sized limestone fragments (estimated at 35% of total matrix). Upon completion of Stratum I, a sub-square was created through a north/south division through the center of the unit. The eastern half of the unit was excavated into Stratum II which was classified as a very dark grayish brown clay. Limestone fragments decreased in Stratum II in opposition to an increase in pebble and gravel sized clasts. The base of Stratum II was not reached in the time accorded for excavation, although an area of light colored sediments was starting to be exposed in the northeast corner indicating a possible Stratum III. Phosphorus levels were recorded as high in Stratum I and not measured in Stratum II.

Table 5. Sediment characteristics of unit 83N-38E.

Stratum	Level	Color	% Sand	% Silt	% Clay	P¹	P²
I	1	10 YR 3/2	28	36	36	3200.19	30.46
II	1	2.5 Y 3/2	26	32	42		

¹ Total Phosphorus

² Extractable Phosphorus

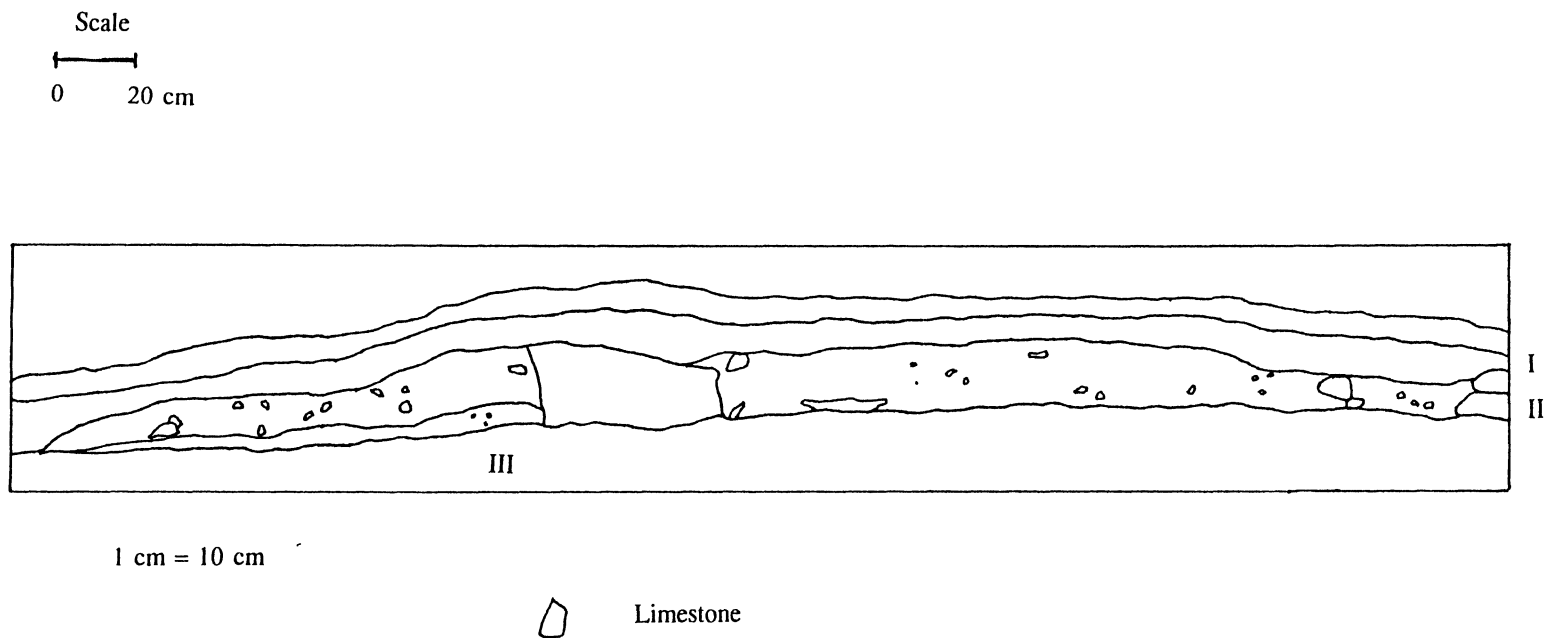


Figure 16. 83N-38E East Wall Profile.

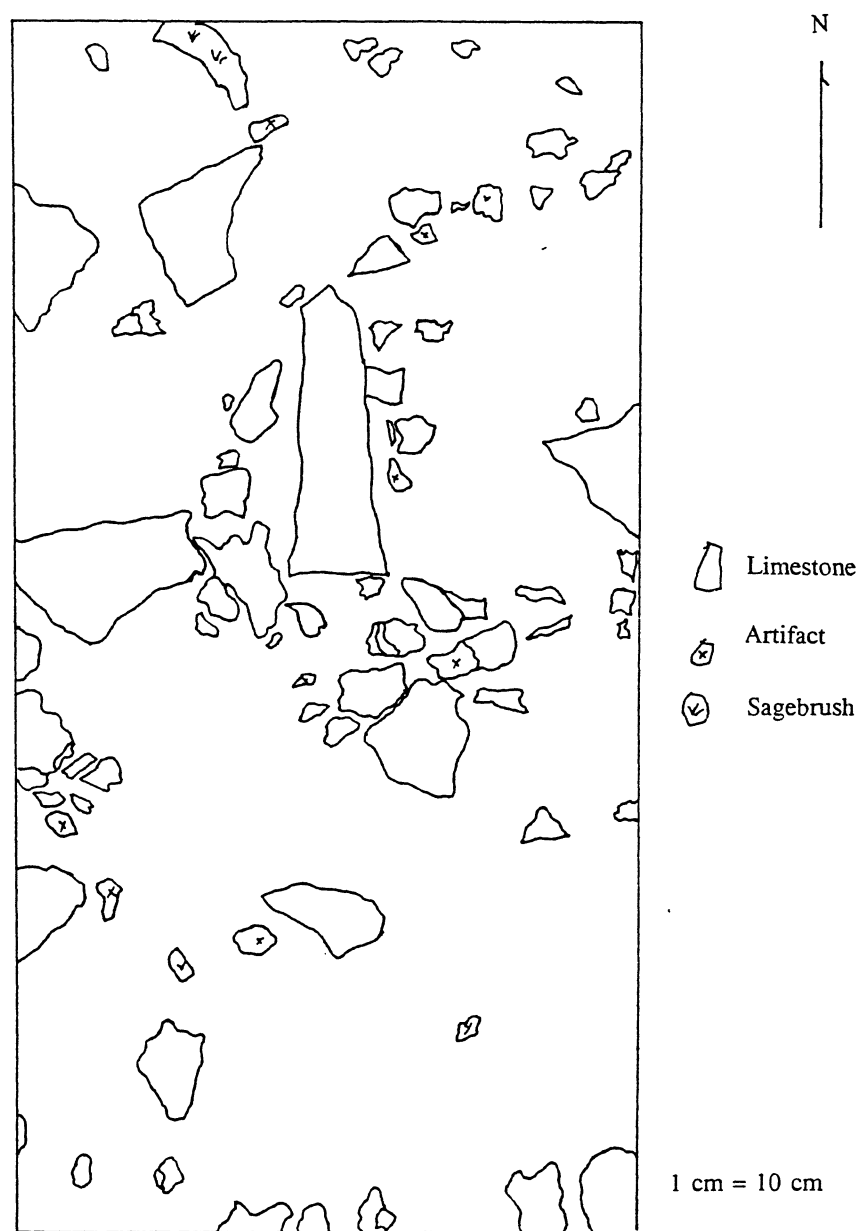


Figure 17. 83N-38E Base of Level 1/Stratum I plan view.

Feature 1

The single feature recorded during the summer field school excavations was located in the southwest corner of excavation unit 18N-31E. This cylindrical pit measured 45cm in diameter by 30cm in depth (Figures 3 and 4). The feature was observed as extending from the base of Stratum I, but with a transition in sediments with higher levels of sand and limestone fragments (Stratum IV). No cultural materials were recovered from the sediments of this feature, although surrounding Stratum (I, II, and III) contained high densities of artifacts. Initial soil studies indicate that the feature is possibly the result human activity or deliberate modification, yet important indicators representing cultural activities (cooking or heating pit) are not present. No evidence of thermal alteration was apparent in the feature fill or surrounding matrix. A speculative possibility is that this pit may have been constructed to act as a quarry tool cache which was eventually filled, by environmental or cultural processes, with quarry pit detritus preceding any lithic reduction activities recorded in Stratum I.

Soil Studies

The soil analysis for this project was a combination of field descriptions (previously discussed in earlier sections) and a particle size distribution and phosphorus content analysis conducted by Dr. Thomas Deluca of the University of Montana School of Forestry.

Rapp and Hill (1998) have show the value of particle size distribution analysis in archaeological contexts. This process can be used to discern stratigraphic and potentially occupational variation, likely sources of postoccupation site disturbances, and soil formation processes (Rapp & Hill 1998).

The strongest benefit of this analysis, as applied to this project, is that it provides a confirmation to the classification of the distinctive strata recorded during the excavations at SPRCQ. Through this analysis we have been able to infer that the sandy loam found in Feature 1 might have derived from wind or water action producing a deposit with a sand content higher than seen throughout the rest of the site. Contrarily, the high quantities of limestone fragments are likely to be too large to have been redeposited within the quarry pits by alluvial agents. Presumably, the limestone fragments (resulting from quarrying activities) were dumped back into exhausted quarry pits by human action. The soils at SPRCQ exhibit the *in situ* context of the sediments as well as quarrying activities. This can be discerned from layered loams and clays from the interior and berms of the quarry pits. The possible extent quarrying activities had in the sedimentary build up at SPRCQ will be addressed in the lithic analysis chapter.

Phosphorus levels in soils have been shown provide an effective means by which to gage human activity within a site. Human actions, such as food preparation and consumption or the depositing of human waste, all leave behind traceable amounts of phosphorus in soils (Hayden 1997:80-82). Soil scientists separate phosphorus or P into two types; inorganic and organic. Inorganic phosphorus is formed through geochemical agent, while organic phosphorus results from plant and animal residue which resist rapid hydrolysis.

Two distinct patterns were observed through the phosphorus analysis. The first pattern is represented in the high amounts of phosphorus found in the upper levels of the excavations with low amounts in the lower levels. Artifact density does not follow this patterning, therefore this pattern can be seen as being suggestive of non-cultural processes.

Cattle grazing in this locale (within the last 100 years) is the most plausible explanation for high phosphate quantities observed in the sediments from the upper levels of the test units. The second pattern is the relatively high phosphate scores in all levels of 75N-39E. Coincidentally, this unit also yielded the highest concentrations of artifacts including lithic tools collected from the excavations. This is most likely indicative high levels of human activity within this quarry pit or near the location of where 75N-39E was placed. This hypothesis shall be further developed in the artifact analysis chapter.

Dating

A single radiocarbon date, using the accelerator mass spectrometry (AMS), was taken from fragment of a bone from a large herbivore, possibly bison, collected from Level 2 of Stratum I in 27N-31E (Figure 11). The bone possibly represent a quarrying tool (digging stick, wedge or a pry). The possible tool was found in the center of the unit in direct association with two exhausted cores. A date of 620 ± 50 B.P. was returned, and after calibration the date was AD 1300-1405 at one stigma and AD 1285-1420 at two stigma. This date would indicate that quarrying activities at QP #4 occurred in the Late Prehistoric period (Frison 1991). This date also concurs with the boundary between the late Little Climatic Optimum and the commencement of the Little Ice Age (Pielou 1991). The date returned from the bone tool is interesting in that northern Wyoming, during the Little Climatic Optimum, has been reported to have been nearly abandoned by prehistoric peoples (Frison 1991; Prentiss 1999). If future dates from this site and quarry pit confirm this occupation, it could be assumed that the activities seen at SPRCQ are evidence of a large scale coordinated effort

to extract a high quality lithic raw material from this source by populations occupying other regions of the Rocky Mountains or Great Plains.

Faunal Analysis

Three faunal remains were recovered from the excavations at SPRCQ during the summer of 1998. The first, which was radiocarbon dated, as discussed in preceding section, was recovered from Level 2 of Stratum I in test unit 27N-31E. This bone is most likely a rib fragment from a large herbivore (bison) and measures 10.11 cm in length by 3.1 cm in width by a maximum thickness of .86 cm. The shallow cut marks on each side are clearly separate from other natural cracking, root “etching”, and other abrasions of an unidentified source. No signs of dental scoring or puncturing are evident on this object. These cut marks are consistent with linear broad “v” shaped incisions described by Binford as “fillet” marks. These types of marks are normally associated with fillet-style butchery, that is, a process used to remove flesh and tendons from bones. Numerous abrasions on both the dorsal and ventral surface of the bone suggest that it had been fabricated into a tool and utilized in quarrying activities until it broke and was subsequently discarded. A second marker identifying this object as a tool is the distal margins of the bone fragment each have some type of modification, possibly cultural. One margin exhibits what has classified as a green bone snap fracture. Although trampling by large animals or humans could be responsible for this break, the context of this object near an area of quarrying must be considered. Possibly the fracture resulted in an inordinate amount of pressure being applied during its use in some type of quarrying activity. The opposite distal end of the bone has been carved in the form of a

broad knife or wedge. This design has been observed and recorded in ethnographic reports mentioning fleshers and digging sticks (Teit 1900; Lowie 1954). Evidence at this point would indicate that the bone fragment was likely used in some sort of digging or prying aspect, possibly to facilitate the extraction of chert and limestone from the quarry pit.

The remaining two faunal pieces include one small unidentifiable piece of bone and one carnivore canine. The canine has been identified as either dog or bear. If this tooth came from the former, it suggests the manifestation of dogs during quarrying occupations. Dogs have been identified as pack animals in prehistoric literature and the likelihood that they were utilized by people in quarrying contexts is possible.

Flotation and Mesodebitage

Flotation analysis was conducted on select soil samples to collect information on the presence of macrobotanical and faunal remains as well as accumulating mesodebitage data. Soil samples were collected from each Stratum of every unit resulting in thirteen samples. Flotation was completed in the archaeological laboratory of the University of Montana utilizing this facilities flotation apparatus. Under the course of this investigation, no faunal or carbonized macrobotanical remains were recovered. A large amount of extra small lithic flakes were recovered. An addition category of “extra-extra” small flakes was created to account for flakes ranging between 1.4-2.9mm in size.

Table 6. Heavy fraction lithic debitage.

<u>Test Unit</u>	<u>Stratum</u>	<u>Level</u>	<u>Medium</u>	<u>Small</u>	<u>X-Small</u>	<u>XX-Small</u>	<u>Total</u>	<u>Ratio of XX -Small/Total</u>
18N-31E	I	1	1	2	16	14	33	.42
18N-31E	II	1	0	6	45	19	70	.27
18N-31E	III	1	0	3	23	16	42	.38
24N-31E	I	1	1	1	18	13	33	.39
24N-31E	I	4	1	4	11	5	21	.24
24N-31E	II	1	0	0	0	4	4	1.0
24N-31E	II	2	0	0	1	0	1	0
27N-31E	I	1	0	4	8	13	25	.52
27N-31E	II	1	0	3	1	0	4	0
75N-39E	I	1	1	13	55	47	116	.41
75N-39E	II	1	2	7	57	36	102	.35
75N-39E	III	1	6	13	130	98	247	.40
81N-38E	I	1	2	11	45	41	99	.41

The category of extra-extra small debitage or “mesodebitage” (Hayden 1997) was created to help define any variation between this data set and the overall debitage assemblages. Mesodebitage studies have been shown by Fladmark (1982) and Schiffer (1987) to be useful in defining overall locations of lithic reduction areas. When reduction areas are cleared after production, small mesodebitage fragments are generally left in place. Areas with corresponding large and mesodebitage assemblages indicate an *in situ* reduction context. For this project, mesodebitage variation was examined by ratio measurements between the extra-

extra small category, collected from the floatation samples, and that of overalldebitage assemblage size (Table 6). Discounting samples with low numbers, the ratios of mesodebitage to overalldebitage groups was consistent with a cluster between .35 and .41 and varying from .24 to .51. This test indicates thatdebitage assemblages collected from the two quarry pits was a result of normal lithic reduction and not the result of dumping or clearing of lithic processing areas.

CHAPTER FOUR

Lithic Analysis

Introduction

Understanding the archaeological record requires not only simple examination and identification of observable patterns represented in material culture, but the incorporation of approaches designed to unify the physical record with the adaptive strategies and individual behaviors manifested in physical remnants from prehistoric populations. Relatively few systematic studies have been performed on lithic procurement sites in northern Wyoming (Light & Church 1980; Francis 1983; Prentiss et al. 1988). This circumstance has left researchers with little understanding of the roles of lithic procurement locales within prehistoric cultural systems. Other research has shown (Elston & Raven 1992; Bamforth 1986; Kelly 1985, 1988; Schott 1989; Nelson 1991; Andrefsky 1994) that variables like access to biotic resources, availability of raw materials, occupational spans, intensity of utilization of lithic materials and tools, lithic procurement strategies, tool maintenance, and transport on tool design, influence the wide range of behaviors and activities observed at quarry sites (Roth & Dibble 1998:47). Occupational episodes at quarry sites may be a reflection of prehistoric mobility, subsistence and technological strategies (Ebert 1992).

The primary goals of the analysis of lithic materials collected from the summer field season at the South Paint Rock Chert Quarries was to ascertain the formation processes at work in a prehistoric chert quarry and to identify the mechanisms and activities (reduction strategies, tool use and export possibilities, quarrying techniques through time) manifested

through the lithic assemblages collected from 48BH245.

This chapter will outline the research goals and analyses of the debitage and tool/core assemblages collected during excavations at the South Paint Rock Chert Quarries, including a description of laboratory techniques and data collection strategies employed for each assemblage. Following these sections, the focus will shift to a brief discussion on statistical considerations and approaches utilized in this investigation. Quantitative data resulting from the lithic analysis will be incorporated in this section.

This analysis was undertaken in hopes that it would provide a greater understanding as to quarrying assemblage formation processes and possibly elucidate the occupational sequences and use patterns at SPRCQ. This investigation will allow preliminary conclusions to be drawn concerning the prehistoric cultural systems evident from the quantitative data and in the archaeological patterns and lithic assemblages observed from the excavations at the South Paint Rock Chert Quarries. These conclusions will be discussed in the subsequent and final chapter.

Analytical Methods

Attempts to bridge the gaps between the physical record and adaptive strategies have been achieved through a variety of middle range theoretical constructs utilizing an assortment of experimental and ethnographic contexts (i.e. Prentiss 1993; Binford 1978, 1979). Experimental studies (cf. Hayden & Hutchings 1989; Mauldin & Amick 1989; Prentiss 1993; Prentiss & Romanski 1989; Prentiss et al. 1988), designed to demonstrate variation within flake tool and debitage assemblages, were incorporated into this analysis.

Debitage Analysis: Methods

Data collection and analysis of materials collected from 48BH245 relied on several distinct attributes. For this project, nine flake variables were recorded from the materials recovered from the summer field excavations at the South Paint Rock Chert Quarries. These attributes were: 1) material type; 2) the presence/absence of thermal alteration; 3) size grades; 4) Sullivan and Rozen's (1985) flake types; 5) cortex percentage; 6) dorsal platform angles; 7) platform wear; 8) blank length; and 9) fracture initiation type. Although all of these categories were not utilized in the statistical analysis of these assemblages, the budgeted laboratory analysis time allowed for extra information to be collected, in hopes of providing any future researchers with complete data sets.

The analysis of thedebitage assemblages from this site relied most heavily on data collected concerning flake breakage characteristics (Prentiss 1993); dorsal cortex cover, as recorded by Mauldin and Amick (1989); striking platform angles (Magne and Pokotylo 1981; Andrefsky 1998; Cotterell & Kamminga 1987; Hayden & Hutchings 1989; Dibble & Whittaker 1981), and data on the types of fracture initiations evident from platform bearing flakes (Cotterell & Kamminga 1987; Hayden & Hutchings 1989). Multiple data sets were chosen for statistical analysis to avoid misinterpretations that often arise in analyses that utilize only a single data set.

Many researchers have demonstrated the utility of flake size and fracture as indicators of reduction strategies and technological variations among lithic assemblages (Sullivan & Rozen 1985; Prentiss 1993; Mauldin & Amick 1989; Sullivan 1987). Data on flake size and breakage characteristics were collected from materials recovered during the summer

excavations but were not a central factor employed for the statistical analysis of the debitage assemblages. Instead the sorting keys of complete, proximal, split, medial/distal and non-orientable (Sullivan and Rozen 1985; Sullivan 1987) were utilized in order to determine flakes with intact platforms. This identification of intact platforms (indicated through split, proximal, and complete flakes) was necessary in the recognition of fracture initiations and to collect metric data on platform angles.

Fracture initiations have been identified by Cotterell and Kamminga (1987) and Hayden and Hutchings (1989) as effective gauges of percussor type. A hard percussor (hammerstone) will typically produce a cone initiation, while a soft percussor (antler, bone, wood) will cause a bending initiation. Depending on the technique used, pressure flaking will produce either a bend or cone initiation. Wedge initiations result from bipolar reduction techniques.

Striking platform attributes have been the subject of many analyses utilizing a variety of measurements and observations. Analyses that are relevant to and utilized in this project focus on the potential of striking platform angles as indicators of percussor types used in lithic reduction (Cotterell & Kamminga 1987; Hayden & Hutchings 1989; Frison 1968), and their capacity to help in the identification of the stage of biface reduction (Dibble & Whittaker 1981; Hayden & Hutchings 1989). Percussor types (hard or soft hammer) are excellent gauges by which to indicate the method of reduction utilized at a flintknapping locales (core reduction vs. biface production respectively). The measure of dorsal or platform edge angles can be a useful means by which to determine percussor types. Flakes exhibiting high dorsal platform angles have been identified by Cotterell and Kamminga (1987) as indicators of core

reduction which is achieved by use of hardhammer percussion. Lower platform angles are conversely asserted by Cottrell and Kamminga (1987) as indicators of softhammer percussion techniques which have been associated with biface or tool production. Dibble and Whittaker's (1981) experiment has led them to argue for the use of exterior striking angle (platform angle) as a useful indicator of stage of reduction. For this analysis, the measure of platform angle was recorded, following Dibble and Whittaker (1981), from each flake with an intact striking platform (complete, proximal, split). Measurements for platform angles were coded into two categories, those angles greater than seventy degrees ($>70^{\circ}$) and those less than seventy degrees ($<70^{\circ}$). The former category was thought to be an indicator of core reduction while the latter a measure of biface/tool production (Dibble & Whittaker 1981).

The measure of dorsal cortex cover in debitage analyses has been accepted by most researchers as a positive indicator of reduction stage of lithic assemblages. High levels of cortex on dorsal surfaces are thought to represent early reduction while low percentages of cortex indicators of a later stage of reduction. Research conducted by Mauldin and Amick (1989) has confirmed that when chert nodules are covered by cortex, dorsal cortex percentage from flaking debris is a good indicator of early phase reduction. In contrast, Sullivan and Rozen (1985) have argued in core reduction scenarios where small amounts or no cortex remains on cores, that dorsal cortex percentage is a poor indicator of reduction stage. For this analysis, the assumption that materials extracted in a quarrying situation would bear higher amounts of cortex, therefore, dorsal cortex percentages would be a good indicator of reduction stages in this context. Percentage breakdowns for cortex cover collected for in

this analysis were divided into three groups: primary (100-75% covered), secondary (75-1% covered), and tertiary (0% covered).

Tool & Core Analysis: Methods

The initial analysis of tools and cores from the South Paint Rock Chert Quarries consisted of typological categorization of all tool types. It is our premise that most tools and cores from SPRCQ are the result of on-site reduction, use, and abandonment. Attempts have been made at developing categories of tools based on morphology. Flake tools have received a number of classifications by various researchers.

Bifaces have also been treated in a similar fashion with numerous roles attributed to this tool type. Kelly (1988) has proposed bifaces fall within three categories: cores, multifunctional tools, and as transportable preforms resulting from the lithic reduction process. Camilli and Ebert (1992) have argued that bifacial cores do not require curation, especially when they are scavenged from a secondary context by new occupants for the purpose of producing expedient flakes. Due to the reality that tool roles is not directly associated with tool form (Binford 1979), we chose not to make curation assumptions during the initial stages of artifact identification.

Flake tools are classified as lithic flakes with evidence of use indicated by intentional edge modification or lateral edge use wear. In this analysis, flake tools are demarcated from formal tools by the presence flake attributes. Flake tools are recognized for this analysis when they display intentional edge modification or use-wear in combination with the characteristics of the flake sorting keys (Sullivan & Rozen 1985; Sullivan 1987) used in the above-mentioned

debitage analysis.

For the purposes of analysis, a descriptive breakdown of flake tools, formal tools, and core types was devised for classificatory and quantitative purposes. The categorical system is as follows:

Flake Tools

- Retouched Flake: any flake with retouch scars manifested upon at least one margin. Retouch scars must be a result of percussion or pressure flake removal, not trampling.
- Utilized Flake: any flake with polishing, rounding, small flake scars, and/or uniform striations along at least one margin. Use patterns must be characteristically attributed to tool use and not trampling.
- Bifacially Retouched Flake: any flake with invasive bifacial retouch along at least one margin.
- Notch: any flake with a single intentional deep notch on at least one margin. This modification is characteristically produced by a single or multiple pressure or percussion flake removals.
- Denticulate: any flake with two or more notch removals from its margins.
- Chopper: any large flake exhibiting use-wear on one or more of its margins demonstrating chopping use. Chopping use is identifiable by high degrees of crushing and deep semi-invasive scarring typified by step and hinge terminations. Cone initiations can also be present in damage caused by chopping activities.
- Side Scraper: any flake featuring a series of regular, invasive retouch along the total length of one lateral margin. Use-wear on these flake tools indicates a scraping use.
- Piercer: any flake with manifesting an acute prominence created by the intersection of a thin broken edge and an abruptly retouched concave lateral margin.

Formal Tools

- Pieces Esquillée: are classified flakes used as wedges. These tools are typically thin and lack large primary flake removals, though flaking may extend partly down the ventral or dorsal faces. Other characteristics include crushing on the ends of the tool and remnants of the original surface still evident (cf. Hayden 1980).
- Stage 2 Biface: corresponding with Callahan's (1979) categories, this is a biface with a thick lenticular cross section. Edge angles, measured from the center of the biface, range between 55 and 75 degrees. The width-thickness ratio is between 2.00 and 3.00. Stage 2 bifaces are the result of initial shaping and thinning activities performed to a flake or a nodule.
- Stage 3 Biface: corresponding with Callahan's (1979) categories, this is a biface which has received primary thinning and has a center edge angle measuring between 40 and 60 degrees. Stage 3 bifaces have a width-thickness ratio ranging between 3.00 and 4.00.
- Stage 4-5 Biface: corresponding with Callahan's (1979) categories, this is a biface which has undergone secondary thinning and shaping. No hafting modifications should be present on this stage of biface manufacture. Johnson (1981) has referred to these bifaces as preforms.
- Other Biface: for this analysis, this category was composed of biface fragments which were unidentifiable as to their stage of reduction from Callahan's (1979) model. Typically, these fragments are small and thin (less than 16 cm²).
- Projectile Point: these are reduced bifaces with a hafting element for attachment to a projectile (spear, arrow, dart). Projectile points are useful in the identification of chronology designations.
- Drill/Borer: a flake with unifacial or bifacial modifications forming a working end and a hafting end. Characteristically, these tools exhibit a worked end with a narrow point, often produced from the distal end of a flake blank.

Core Types

- Core: in general, lithic materials reduced to produce flakes. Reduction is accomplished by using a hard hammer (hammerstone). Platforms are traditionally prepared and flake size relates to the size of the core being reduced. Core types were further delineated morphologically by Callahan (1979) as spheroid, block, or tabular.

- Single platform core: a core produced by freehand percussion distinguished by flake removals from a single prepared/shaped striking platform. Comparable to Callahan's (1979) block core.
- Multi-platform core: a core produced by free-hand percussion distinguished by flake removals from multiple striking platforms. Striking platforms can be prepared or unprepared. Comparable to Callahan's (1979) spheroid core.
- Tested nodule: any nodule bearing one flake removal.
- Bipolar Core: this can be a tool/nodule/exhausted core reduced to produce flakes. Reduction of a bipolar core is accomplished by a hammer and anvil technique. This technique can be distinguished by basal and platform crushing, sheared bulbs of force, compression-controlled propagations, wedge initiations, and flake scars typically blanketing the face of the core.
- Levallois core: this distinctive core is characterized by a nodule that has been reduced to form a core that will produce specific types of flake when worked. These cores show evidence of previous flake removals which generally give the base a conical shape and a domed dorsal surface with a characteristic lateral striking platform area.

OVERVIEW - LITHICS DATA

Excavation Units: Quarry Pit #4

18North - 31East

Stratum I, II, and III all yielded high numbers of artifacts with Stratum IV lacking cultural materials (Table 7). Considerable numbers of flakes, with varying degrees of dorsal cortex cover, and large number of cores from this unit, possibly suggest that core reduction was the primary quarrying activity represented at this location. Flake tools were also recovered from this unit. Nearly 40 % of the flake tools collected from this unit were notches or denticulates. These tools have been associated in the past with shaving shaft-tools (cf.

Hayden 1979) such as wedges and digging sticks.

Table 7. Artifacts recovered from unit 18N-31E

Artifacts	Stratum/Level						Total
	I/1	I/2	I/3	II/1	II/2	III/1	
Primary Flakes	305	7	9	22	70	33	446
Secondary Flakes	474	81	16	214	81	36	902
Tertiary Flakes	503	33	15	127	108	126	912
Multiplatform Flakes	16	3	1	19	7	8	54
Single Platform Core	2	4	2	2	1	2	13
Bipolar Core	6	1		7	1	1	16
Pieces Esquillée							
Tested Nodule	1	4	2	1	1	3	12
Hammerstone	3	1		2	2		8
Retouched Flake	2			2			4
Bifacially Retouched Flake							
Utilized Flake				3			3
Notch						1	1
Denticulate	1	1		1			3
Stage Two Biface				1			1
Other Biface							
Drill/Borer							
Total	1313	135	45	401	271	210	2375

24North - 31East

All stratum from 24N-31E yielded artifacts (Table 8). Cortex bearing flakes and multiple platform cores were the prevailing artifact type, followed by low numbers of additional core types. The low levels of artifacts represented in this unit indicate that tasks resulting in the casting off spent tools was not common in this area. Low numbers of

debitage do indicate lithic reduction was performed in this locale but not to the extent as it was in other areas. Several factors may account for low levels in artifacts anddebitage from this unit. First, the sediments of this unit may be out of context, possibly having been disturbed by people engaged in quarrying activities or spoil management. Second, natural processes could have disturbed the context of the area. The sloping interior of 24N-31E on the inside of the quarry pit could have been derived in part from berm slumpage.

Table 8. Artifacts recovered from unit 24N-31E

Artifacts	Stratum/Level							Total
	I/1	I/2	I/3	I/4	I/5	II/1	II/2	
Primary Flake	21	4	5	13			25	68
Secondary Flake	49	14	28	28	7	7	73	206
Tertiary Flake	53	3	26	21	10	2	80	195
Multiplatform Core	5	2	8	3		3		21
Single Platform Core	6							6
Bipolar Core	3	4	1					8
Tested Nodule	2	1				3		6
Pieces Esquillée	1							1
Hammerstone		1	1					2
Retouched Flake		2	1				1	4
Bifacially Retouched Flake	1							1
Utilized Flake								
Notch								
Denticulate			1					1
Stage Two Biface			1					1
Other Biface								
Drill/Borer								
Total	141	31	72	65	17	15	179	520

27North - 31East

Artifact distributions were present in all levels of 27N-31E (Table 9), with the highest concentrations in levels 2, 3, and 4 of Stratum 1. Cortex bearing flakes dominated the assemblage. A small number of flake tools and cores comprised the rest of the artifacts recovered. Denticulates and notches were the leading type of flake tool represented in this unit.

Table 9. Artifacts recovered from unit 27N-31E

Artifacts	Stratum/Level						II/2	Total
	I/1	I/2	I/3	I/4	I/5	II/1		
Primary Flake	9	73	105	18	2	6		213
Secondary Flake	67	94	354	81	9	11	2	618
Tertiary Flake	63	212	198	88	19	13	2	595
Multiplatform Core		2	8					10
Single Platform Core			2					2
Bipolar Core	1		7	3				11
Tested Nodule			2	3				5
Pieces Esquillée	2							2
Hammerstone	1	2	3	1				7
Retouched Flake				1				1
Bifacially Retouched Flake								
Utilized Flake		1						
Notch			1	1				2
Denticulate	1							1
Stage Two Biface								
Other Biface								
Drill/Borer								
Total	144	384	680	196	30	30	4	1467

Excavation Units: Quarry Pit #7**75North - 39East**

The highest artifact densities were found in unit 75N-31E (Table 10). Debitage numbers were dominated by tertiary flakes with cortex bearing flakes the next highest category. The majority of the tertiary flakes recovered from this unit were classified in the small to extra small size grade. Numerically, multi-platform cores, bipolar cores, and hammerstones were the dominant tool type from this unit. A variety of flake tools and bifaces were also recovered. The level of notch and denticulate tools coincided with amounts seen in the other units. Artifact densities within the unit were highest in Level 1 of Stratum I and in Levels 1 and 3 of Stratum III. Artifact patterning appears to be relatively uniform between levels. Initial analysis of the artifacts from this unit would indicate a dominant pattern of intensive core reduction occurring throughout all levels, although other modes of reduction can be seen through the samples as well.

Table 10. Artifacts recovered from unit 75N-39E

Artifacts	Stratum/Level					Total
	I/1	II/1	III/1	III/2	III/3	
Primary Flake	659	102	227	2	29	1019
Secondary Flake	998	292	1374	24	52	2740
Tertiary Flake	1570	830	2583	43	91	5117
Multiplatform Core	9	1	110	3	7	130
Single Platform Core			14		1	15
Bipolar core	7		26		1	34
Pieces Esquillée			1			1
Tested Nodule		1			1	2
Hammerstone	5		30		1	36
Retouched Flake	5		8			13
Bifacially Retouched Flake			1			1
Utilized Flake	6	1	5			12
Notch	2		5			7
Denticulate			3			3
Stage Two Biface			8		1	9
Other Biface						
Drill/Borer	1					1
Total	3262	227	4395	72	184	9140

83North - 38East

Numerous artifacts were retrieved from all levels of 83N-38E (Table 11). Abundant levels of cortex bearing flakes again suggest an emphasis on the early stage reduction and decortication of chert nodules. The large numbers of discarded cores supports this assumption. Tool types are primarily represented by notches/denticulates and retouched flakes.

Table 11. Artifacts recovered from unit 83N-38E

Artifacts	Stratum/Level		Total
	I/1	II/1	
Primary Flakes	101	26	127
Secondary Flakes	223	93	316
Tertiary Flakes	386	81	467
Multiplatform Core	13	5	18
Single Platform Core	2	3	5
Bipolar Core	11	4	15
Tested Nodule	1		1
Pieces Esquillée			
Hammerstone	4	1	5
Retouched Flake	7	1	8
Bifacially Retouched Flake			
Utilized Flake			
Notch	1		1
Denticulate	2		2
Stage Two Biface			
Other Biface		1	1
Drill/Borer			
Total	751	215	966

Statistical Analyses

The statistical analysis of lithic assemblages (debitage and tool) was primarily conducted utilizing Chi square and Correlation tests. Chi square is useful because it helps researchers to determine significant correlations between two variables. Bivariate correlation tests were also conducted to examine the relationships between flake production and core reduction from quarry pits #4 and #7 and the role of transportation of lithic products.

To begin this analysis, coding and provenience data for both debitage and tool assemblages were finalized. Data sets for debitage were established on initiation type and platform angles and were further categorized by excavation unit and provenience. Tool data sets were organized by the categories Functional Tools and Shaping-Reduction Tools. Data sets from tool categories were also divided according to excavation unit and provenience. The designation of Functional Tools was further divided into five additional categories: 1) scrapers; 2) utilized/retouched flakes; 3) bifaces/bifacially retouched flakes; 4) notches/denticulates; and 5) drills/borers/piercers/choppers/hammerstones. Shaping-Reduction Tool data sets were created for this analysis to measure variation in reduction techniques. This data set was subdivided into five additional categories: 1) non-bifaces/expedient tools; 2) shaped bifaces 3) single/multi-platform cores; 4) tested nodules; and 5) bipolar cores.

Chi-square tests were employed to determine if our samples, representing reduction activities, were significantly different when looking at the levels of each excavation unit and between the quarry pits. By doing this, I wished to examine the question of which levels sampled were from continuous or discontinuous lithic reduction episodes. For the Chi-

square tests of the debitage assemblages from South Paint Rock Chert Quarries a “Null Hypothesis” was established predicting that lithic reduction patterns would not be recognizable from the initiation types (cone, bend, wedge) and platform angles greater than or less than seventy degrees ($>70^\circ$ or $<70^\circ$). If the Chi-square test scores for initiation types and platform angles were above the established critical values, then the Null Hypothesis would be rejected and materials tested are determined as samples from independent populations representing different types or techniques of lithic reduction. If the scores fall below the critical value then the Null Hypothesis would be accepted, indicating the levels represent samples drawn from the same kind of reduction. Correlation tests were performed to discern the relation between flake and core types. It was hoped that these tests would further elucidate the dominant lithic reduction modes and uses for the raw materials sampled from the two quarry pits excavated during this project. Bivariate correlation tests are useful in measuring the degree of relationship between two variables. Two variables, each with three possible statuses, were used for this test. They are based on initiation type and core type, basic core, bifaces and bipolar cores respectively.

It is assumed in this analysis that the measure of the correlation between hard hammer (cone) flakes to cores will provide information as to the degree by which cores were transported from the site or used on site to produce materials and tools for quarrying activities. A positive correlation between cone initiation flakes and cores will demonstrate hard hammer core reduction activities occurred at this locale. This would show that hard hammer lithic reduction activities were centered on-site and were likely geared towards the production of flakes, possibly for expedient tools used to aid quarrying activities. Conversely,

low numbers of cone initiation flakes in conjunction with low numbers of cores will indicate that hard hammer lithic reduction was not a primary reduction activity at this site. A negative correlation between cone initiation flakes and cores could demonstrate two things. High numbers of cone initiation flakes in conjunction with low numbers of cores would indicate that cores were fashioned for export. High numbers of cores with low numbers of cone initiation flakes would connote that hard hammer reduction was carried out with the intent of producing flakes which could be utilized for expedient tools or exported off site for future use and refinement.

A soft hammer (bend) flake to biface correlation analysis will provide similar information as to the role of bifaces at this site and whether they were produced for on site use or to be transported off site for further refinement. A positive correlation between the two variables for this analysis provides two options. First, high numbers of bend initiation flakes coupled with high numbers of bifaces should indicate that flakes were worked towards the goal of producing bifaces or tools used in supporting on-site activities. Second, low numbers of bend initiation flakes and bifaces would indicate that biface production was minimal part of lithic reduction activities in the area. A negative correlation between these two variables would likewise indicate one of two things. High numbers of bend initiation flakes paired with low numbers of bifaces would indicate that bifaces were produced on-site but were then transported off-site for further refinement. High numbers of bifaces with low frequencies of bend initiation flakes would indicate either the bifaces found in association with the quarry pits were produced at another locale and then imported to the pits for use in quarrying or that the context of the area was disturbed, possibly by sweeping/cleaning

activities or erosion, and the bend initiation flakes produced in the production of bifaces were removed from the area.

And finally, the relationship between wedge initiation (wedge) flakes and bipolar cores must be considered. Likewise were these flakes produced for on-site use or for transport off site? A positive correlation between these two variables would indicate one of two things. High numbers of wedge initiation flakes and bipolar cores would indicate an utilization of exhausted cores, through bipolar reduction, for the purpose of producing expedient flakes. Low numbers of wedge initiation flakes coupled with low numbers of bipolar cores would indicate that bipolar reduction was not utilized to a great extent in quarrying or lithic reduction process at the quarry pits. A negative correlation between these two variables also has two possible explanations. First, a high occurrence of wedge initiation flakes in conjunction with low numbers of bipolar cores would indicate that bipolar reduction was utilized to produce expedient flakes and the cores utilized to produce these flakes were discarded once all viable platforms were exhausted. Second, a high rate of bipolar cores in proportion to low numbers of wedge initiation flakes would reflect that bipolar cores were utilized to produce flakes, most likely for expedient, quarrying related activities such as constructing digging sticks or preparing food.

Chi-square analysis for initiations

The Chi-square analysis conducted for initiation types for all excavation units (Tables 12-15) were organized with three initiation types, cone, bend, and wedge as one variable. The second variable was the stratum of the excavation unit. Excavation units 18N-31E and

75N-39E each contained three distinct stratum, while excavation units 24N-31E, 27N-31E, and 83N-38E contained two distinct stratum. Degrees of freedom for both 18N-31E and 75N-39E was calculated at four ($df = 4$). Degrees of freedom for the remaining three units is two ($df = 2$). All scores were compared to the Critical values for χ^2 at 0.050 percent or to a 95% probability.

18N-31E initiations

For the Chi-square analysis for this unit a critical value (χ^2) greater than 9.48733 was needed to reject the null hypothesis. A score of 9.3042134 was recorded for this test of 18N-31E (Table 12). This would indicate that the null hypothesis was supported in this analysis; therefore, no significant difference between initiation types or reduction strategies was discernable within the strata of this unit. The relative frequencies for initiations from this unit suggests that reduction activities from the three strata were primarily oriented towards hard hammer reduction with a secondary emphasis on soft hammer reduction.

Table 12. 18N-31E Chi-square: initiations

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/E
stratum 1	CONE	57	50.72	6.28	5.78	33.4084	0.658683
	BEND	17	21.19	-4.19	-4.69	21.9961	1.0380415
	WEDGE	0	2.08	-2.08	-2.58	6.6564	3.2001923
stratum 2	CONE	75	80.2	-5.2	-5.7	32.49	0.4051122
	BEND	36	33.51	2.49	1.99	3.9601	0.1181767
	WEDGE	6	3.3	2.7	2.2	4.84	1.4666667
stratum 3	CONE	14	15.08	-1.08	-1.58	2.4964	0.1655438
	BEND	8	6.3	1.7	1.2	1.44	0.2285714
	WEDGE	0	0.62	-0.62	-1.12	1.2544	2.0232258
						$\chi^2 =$	9.3042134

24N-31E initiations

A critical value (χ^2) greater than 5.99147 was needed to reject the null hypothesis for the Chi-square test for this unit. A score of 2.8753122 was recorded (Table 13). The null hypothesis was accepted in this test. No clear distinction between initiation types was apparent within the strata for this unit. The quantitative data for initiations from the two strata of this unit would indicate that both hard hammer reduction and soft hammer reduction activities were carried out within this quarry pit with a slightly higher occurrence of hard hammer reduction indicated by higher relative numbers. The location of this unit within the interior or the quarry pit could also have relevance as to the fairly equal distribution of cone and wedge initiation flakes and could likely be the result of backfilling activities after material extraction and reduction.

Table 13. 24N-31E Chi-square: initiations

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/E
stratum 1	CONE	37	38.32	-1.32	-1.82	3.3124	0.0864405
	BEND	14	16.2	-2.2	-2.7	7.29	0.45
	WEDGE	2	1.47	0.53	0.03	0.0009	0.0006122
stratum 2	CONE	15	13.68	1.32	0.82	0.6724	0.049152
	BEND	5	5.79	-0.79	-1.29	1.6641	0.2874093
	WEDGE	0	0.53	-0.53	-1.03	1.0609	2.0016981
						$\chi^2 =$	2.8753122

27N-31E initiations

This test was dropped due to insufficient data.

75N-39E initiations

A critical value (χ^2) greater than 9.48773 was needed to reject the null hypothesis for the Chi-square test of initiations for this unit. A score of 33.313747 was recorded for this test (Table 14). This score indicates that the null hypothesis is rejected. The results from this test indicate that there are recognizable differences in reduction strategies by stratum. The quantitative data suggests that in the lowest levels (stratum III) there was a higher than expected occurrence of bend initiation, or soft hammer reduction flakes. In Stratum II bend initiations fall off and cone initiations occur in higher frequencies. By the uppermost levels (Stratum I) a higher than expected level of cone initiations, or hard hammer reduction flakes, are evident. Wedge initiations remained negligible throughout all strata from this unit. This data would indicate that the lowest levels of this unit show a strong correlation with biface/tool production activities. The opposite is true for the upper levels, data indicates that

a shift occurs in reduction strategies toward core reduction.

Table 14. 75N-31E Chi-square: initiations

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/E
stratum 1	CONE	136	116.15	19.85	19.35	374.4225	3.2236117
	BEND	15	33.39	-18.39	-18.89	356.8321	10.686795
	WEDGE	0	1.45	-1.45	-1.95	3.8025	2.6224138
stratum 2	CONE	73	72.31	0.69	0.19	0.0361	0.0004992
	BEND	17	20.79	-3.79	-4.29	18.4041	0.8852381
	WEDGE	4	0.9	3.1	2.6	6.76	7.5111111
stratum 3	CONE	271	291.54	-20.54	-21.04	442.6816	1.5184249
	BEND	106	83.82	22.18	21.68	470.0224	5.6075209
	WEDGE	2	3.64	-1.64	-2.14	4.5796	1.2581319
						$\chi^2 =$	33.313747

83N-31E initiations

For the Chi-square analysis for this unit a critical value (χ^2) greater than 5.99147 was needed to reject the null hypothesis. A score of 10.428352 was recorded rejecting the null hypothesis (Table 15). Stratum II demonstrates a higher than expected frequency of cone initiations with a lower than expected occurrence of bend initiation flakes indicating an early propensity toward core reduction. In Stratum I bend initiations exceed the expected number. This can be explained as a shift from core reduction to biface/tool production in the latter levels. The quantitative data coupled with the statistical data indicates that core reduction was the prevalent form of lithic reduction in Stratum II while in Stratum I there was a shift in strategy to that of tool production.

Table 15. 83N-38E Chi-square: initiations

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/E
stratum 1	CONE	61	67.59	-6.59	-7.09	50.2681	0.743721
	BEND	39	32.65	6.35	5.85	34.2225	1.0481623
	WEDGE	1	0.76	0.24	-0.26	0.0676	0.0889474
stratum 2	CONE	28	21.41	6.59	6.09	37.0881	1.7322793
	BEND	4	10.35	-6.35	-6.85	46.9225	4.5335749
	WEDGE	0	0.24	-0.24	-0.74	0.5476	2.2816667
						$\chi^2 =$	10.428352

Chi-square analysis for platform angles

The Chi-square analysis conducted for platform angles for all excavation units (Tables 16-19) divided platform angles into two types: those platform angles greater than seventy degrees ($>70^\circ$) and platform angles less than seventy degrees ($<70^\circ$). The second variable was the stratum of the excavation unit. To determine the expected frequencies for this analysis, a goodness of fit test was conducted for each variable from each stratum of all excavation units. Degrees of freedom for both 18N-31E and 75N-39E was calculated at two ($df = 2$). Degrees of freedom for the remaining three units was determined to be one ($df = 1$). All scores were compared to the Critical values for χ^2 at 0.050 percent, or a 95% certainty.

18N-31E platform angles

For the Chi-square analysis for this excavation unit a critical value (χ^2) greater than 5.99147 was needed to reject the null hypothesis for platform angles. A score of 3.4798457

was recorded for this test of 18N-31E (Table 16). The null hypothesis was supported in this analysis, demonstrating that there are no significant differences between the platform angles from the three strata of this unit.

Table 16. 18N-31E Chi-square: platform angles

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/E
stratum 1	>70	39	33.7	5.3	4.8	23.04	0.6836795
	<70	35	40.3	-5.3	-5.8	33.64	0.8347395
stratum 2	>70	51	53.28	-2.28	-2.78	7.7284	0.1450526
	<70	66	63.72	2.28	1.78	3.1684	0.0497238
stratum 3	>70	7	10.02	-3.02	-3.52	12.3904	1.2365669
	<70	15	11.98	3.02	2.52	6.3504	0.5300835
						$\chi^2 =$	3.4798457

24N-31E platform angles

A critical value (χ^2) greater than 3.84146 was needed to reject the null hypothesis for the Chi-square test for this unit. A score of 0.2091266 was tabulated for the Chi-square test for platform angles from this unit (Table 18), well below the critical value needed to reject the null hypothesis. Both hard hammer and soft hammer reduction activities are evident within each stratum with a higher occurrence of platform angles less than ($<70^\circ$) seventy degrees implying that soft hammer percussion (tool production) occurred in greater frequency, for the strata of this unit, than hard hammer percussion (core reduction).

Table 17. 24N-31E Chi-square: platform angles

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/E
stratum 1	>70	19	18.42	0.58	0.08	0.0064	0.0003474
	<70	37	37.58	-0.58	-1.08	1.1664	0.0310378
stratum 2	>70	6	6.58	-0.58	-1.08	1.1664	0.1772644
	<70	14	13.42	0.58	0.08	0.0064	0.0004769
						$\chi^2 =$	0.2091266

27N-31E platform angles

As with the test for initiations from this unit, a low sample size has resulted in the dropping of this test.

75N-39E platform angles

A critical value (χ^2) of 5.99147 was needed to reject the null hypothesis for this test. This test registered a score of 5.008917, which is below the critical value needed and therefore in this test the null hypothesis is accepted (Table 18).

Table 18. 75N-39E Chi-square: platform angles

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/E
stratum 1	>70	41	43.32	-2.32	-2.82	7.9524	0.1835734
	<70	110	107.68	2.32	1.82	3.3124	0.0307615
stratum 2	>70	19	26.96	-7.96	-8.46	71.5716	2.6547329
	<70	75	67.04	7.96	7.46	55.6516	0.8301253
stratum 3	>70	119	108.72	10.28	9.78	95.6484	0.8797682
	<70	260	270.28	-10.28	-10.78	116.2084	0.4299556
						$\chi^2 =$	5.008917

83N-38E platform angles

A critical value (χ^2) greater than 3.84147 was needed to reject the null hypothesis for the Chi-square test for this unit. A score of 1.3021592 was recorded for this test (Table 19). No distinction could be ascertained between the platform angles in the strata of 83N-38E. Both hard hammer and soft hammer reduction activities were evident within the strata of this unit.

Table 19. 83N-38E Chi-square: platform angles

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/E
stratum 1	>70	62	59.23	2.77	2.27	5.1529	0.0869981
	<70	39	41.77	-2.77	-3.27	10.6929	0.2559947
stratum 2	>70	16	18.77	-2.77	-3.27	10.6929	0.5696803
	<70	16	13.23	2.77	2.27	5.1529	0.389486
						$\chi^2 =$	1.3021592

Special Analyses

Data gained from the initial analyses of debitage and tool/core assemblages from 75N-31E and 83N-38E showed potential to clarify the context of quarrying activities from quarry pit #7. It was decided that new data sets should be collected from the code sheets and Chi-square tests run on dorsal Cortex Percentage and Flake Size. Many researchers have demonstrated the utility of flake size and fracture as indicators of reduction strategies and technological variations among lithic assemblages (Mauldin & Amick 1989; Prentiss 1993). Dorsal cortex cover in debitage analyses has also been accepted by researchers as a positive

indicator of reduction stage of lithic assemblages (Mauldin & Amick 1989). It was hoped these new tests would confirm earlier conclusions. As before, the data sets for cortex percentage and flake size were divided by excavation unit and by stratum.

Variables for cortex percentage were divided into three categories. These categories are: primary (100-75% covered), secondary (75-1% covered), and tertiary (0% covered). The variables for the flake size Chi-square tests were based on the size grade scale that was utilized during the data coding of lithic assemblages. The data set for flakes consisted of five size classifications: extra-small ($<1\text{cm}^2$); small ($1-4\text{cm}^2$); medium ($4-16\text{cm}^2$); large ($16-64\text{cm}^2$); and extra-large ($>64\text{cm}^2$). It must be stated that the variability between flake size makes it more difficult to hypothesize about the results testing. Where the cut-off between flake sizes is, in relation to mode of reduction, is based on arbitrary decisions.

For the first test, a Null Hypothesis was established predicting the Chi-square test for cortex percentage was from common population. A score exceeding the critical value, coupled with the pattern, would help determine the dominant mode of lithic reduction represent through the observed data sets and stratum.

As with cortex percentage test, a Null Hypothesis was established predicting that the Chi-square test for flake size would indicate that there was no relationship between the stratum and flake size. Furthermore, if the score for this test exceeded the critical value, then the Null Hypothesis would be rejected and data sets for flake size were likely derived from independent populations and distinct reduction activities or techniques. The distribution of flake size by stratum, with a score above the critical value, would help to define the prevalent mode of reduction activities.

As previously noted, excavation unit 75N-39E contained three distinct strata and excavation unit 83N-38E encompassed two distinct strata. Degrees of freedom for 75N-39E was calculated at eight ($df = 8$) while the degrees of freedom for 83N-38E was determined to be four ($df = 4$). All scores were compared to the Critical values for χ^2 at 0.050 percent.

75N-39E Flake Cortex Percentage

The Chi-square analysis for cortex percentage data set from 75N-39E needed a score of 9.48733 to reject the null hypothesis. A score of 64.01356 was recorded for this test indicating that the null hypothesis is rejected (Table 20). This test unquestionably rejects the null hypothesis and supports the earlier conclusions concerning lithic reduction activities manifested in the debitage assemblages from 75N-39E. The lowest levels of the unit (Stratum III) show clear indicators of biface/tool production with higher than expected numbers of tertiary and secondary flakes. Primary flakes were observed in lower frequencies than expected. This data corroborates data seen from initiation types but contradicts the acceptance of the null hypothesis in the platform angles test.

In Stratum II, the observed count of tertiary flakes was once again higher than expected levels while secondary flakes fell below expected levels. Primary flakes in this stratum exceed the expected levels indicating, as in the data from initiations for this unit, that while biface/tool production continues through this strata, a shift in reduction strategies is occurring towards core reduction.

Stratum I confirms the shift from biface/tool production to core reduction. Primary

flakes, or core reduction, are observed at levels significantly above the expected levels, while secondary flakes are within the expected range and tertiary flakes fall well below expected levels indicating that core reduction was the focus of lithic reduction activities in Stratum I. The new evidence from the cortex percentage Chi-square test confirms and supports the conclusions drawn from the test of initiation types.

Table 20. 75N-39E Chi-square: flake cortex percentage

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/E
stratum 1	primary flake	131	82.56	48.44	47.94	2298.2436	27.837253
	secondary flake	310	312.04	-2.04	-2.54	6.4516	0.0206756
	tertiary flake	390	436.4	-46.4	-46.9	2199.61	5.0403529
stratum 2	primary flake	54	43.02	10.98	10.48	109.8304	2.5530079
	secondary flake	123	162.59	-39.59	-40.09	1607.2081	9.8850366
	tertiary flake	256	227.39	28.61	28.11	790.1721	3.4749642
stratum 3	primary flake	210	269.43	-59.43	-59.93	3591.6049	13.330382
	secondary flake	1060	1018.36	41.64	41.14	1692.4996	1.6619855
	tertiary flake	1442	1424.21	17.79	17.29	298.9441	0.2099017
						$\chi^2 =$	64.01356

primary flake (100-75% covered), secondary flake (75-1% covered), and tertiary flake (0% covered)

83N-38E Flake Cortex Percentage

For the Chi-square analysis of flake cortex percentage a critical value (χ^2) of 5.99147 was needed to reject the null hypothesis. A score of 6.8832479 was obtained (Table 21) rejecting the null hypothesis. Evidence indicates that, in Stratum II of this unit, levels of observed tertiary flake production were lower than expected, while secondary and primary flake numbers were slightly above expected levels. In Stratum I there is a shift in observed versus expected levels of tertiary flakes rising above expected frequencies. Primary and

secondary flakes from this stratum fall below expected levels. Data from this test corroborates the evidence seen from initiation types for both stratum from this unit. Evidence from the Chi-square test, in conjunction with the quantitative figures, indicate that the primary lithic reduction activities in Stratum II were centered on core reduction. Low levels of tertiary flakes connote that cores with high percentages of cortex were being extracted and reduced. A shift of reduction strategies occurs in Stratum I from core reduction to biface/tool production. These results confirm the conclusions seen with the analysis of initiations.

Table 21. 83N-38E Chi-square: flake cortex percentage

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/E
stratum 1	primary flake	95	98.02	-3.02	-3.52	12.3904	0.1264069
	secondary flake	232	243.82	-11.82	-12.32	151.7824	0.6225183
	tertiary flake	402	387.15	14.85	14.35	205.9225	0.5318933
stratum 2	primary flake	24	20.98	3.02	2.52	6.3504	0.3026883
	secondary flake	64	52.18	11.82	11.32	128.1424	2.4557762
	tertiary flake	68	82.85	-14.85	-15.35	235.6225	2.843965
						$\chi^2 =$	6.8832479

primary flake (75-100% covered), secondary flake (1-75% covered), and tertiary flake (0% covered)

75N-39E Flake Size

For this Chi-square analysis a critical value (χ^2) greater than 15.5073 was needed to reject the null hypothesis. A score of 213.29054 was recorded for this test (Table 22). In Stratum III, observed numbers of flakes are close to the expected frequencies except for the categories of large (16-64 cm²) and extra-large (>64 cm²) which exceed the expected figures. Stratum II displays a drop in observed from expected flakes in the extra-large (>64 cm²),

large (16-64 cm²), and small (1-4 cm²) categories. Flakes from the medium (4-16 cm²) and extra-small (<1 cm²) groups exceed their expected frequencies. All flake size categories but small flakes (1-4 cm²) in Stratum I of this unit exhibited numbers below expected levels.

This test indicates that in Stratum III there was an emphasis on the reduction of cores as evident through a higher than expected occurrence of large and extra-large flakes. The production of large flakes from this test concurs with earlier predictions of early stage biface manufacture through the use of these large flakes. Data from Stratum II indicates a shift to biface/tool production with a low occurrence of extra-large (>64 cm²) and large (16-64 cm²) and greater than expected numbers of extra-small (<1 cm²) and medium (4-16 cm²) flakes. The data from Stratum I of this unit is somewhat difficult to interpret. All categories of flake size but small flakes fall below expected levels. Biface production appears to be the primary mode of lithic reduction represented within the materials from this strata.

Table 22. 75N-39E Chi-square: flake size

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/
stratum 1	x-sm flakes (<1 cm ²)	132	204.81	-72.81	-73.31	5374.3561	26.24066
	sm flakes (1-4 cm ²)	447	325.43	121.57	121.07	14657.945	45.04177
	med flakes (4-16 cm ²)	232	244.39	-12.39	-12.89	166.1521	0.679864
	lg flakes (16-64 cm ²)	51	84.6	-33.6	-34.1	1162.81	13.74479
	x-lg flakes (>64 cm ²)	1	3.77	-2.77	-3.27	10.6929	2.83631
stratum 2	x-sm flakes (<1 cm ²)	183	104.42	78.58	78.08	6096.4864	58.38427
	sm flakes (1-4 cm ²)	86	165.92	-79.92	-80.42	6467.3764	38.97888
	med flakes (4-16 cm ²)	146	124.6	21.4	20.9	436.81	3.505698
	lg flakes (16-64 cm ²)	25	43.14	-18.14	-18.64	347.4496	8.054000
	x-lg flakes (>64 cm ²)	0	1.92	-1.92	-2.42	5.8564	3.050208
stratum 3	x-sm flakes (<1 cm ²)	663	668.77	-5.77	-6.27	39.3129	0.058783
	sm flakes (1-4 cm ²)	1021	1062.65	-41.65	-42.15	1776.6225	1.671879
	med flakes (4-16 cm ²)	789	798.01	-9.01	-9.51	90.4401	0.11333
	lg flakes (16-64 cm ²)	328	276.26	51.74	51.24	2625.5376	9.503864
	x-lg flakes (>64 cm ²)	17	12.31	4.69	4.19	17.5561	1.426165
						$\chi^2 =$	213.2905

83N-38E Flake Size

For the flake size analysis for this unit, a critical value (χ^2) greater than 9.48773 was needed to reject the null hypothesis. A score of 43.267774 was tabulated at a significant level. Stratum II exhibited frequencies of extra-large (>64 cm²), large (16-64 cm²), and medium (4-16 cm²) that surpassed expected levels. This information indicates that biface production was the focus of lithic reduction within this stratum. Flake size in Stratum I shifts to higher than expected numbers of extra-small (<1 cm²) and small (1-4 cm²) flakes with lower than predicted number of the other size grades. Byproducts of hard hammer core reduction are small to extra-small flakes and platform angles greater than seventy degrees. Using flake size as a determinate for the type of reduction technique suggests that a focus on biface production occurred in Stratum II while core reduction was the dominant reduction

activity employed in Stratum I.

Table 23. 83N-38E Chi-square: flake size

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE
stratum 1	x-sm flakes (<1 cm ²)	164	148.7	15.3	14.8	219.04	1.4730
	sm flakes (1-4 cm ²)	389	367.85	21.15	20.65	426.4225	1.15922
	med flakes (4-16 cm ²)	158	187.84	-29.84	-30.34	920.5156	4.90053
	lg flakes (16-64 cm ²)	20	25.83	-5.83	-6.33	40.0689	1.55125
	x-lg flakes (>64 cm ²)	0	0.78	-0.78	-1.28	1.6384	2.10051
stratum 2	x-sm flakes (<1 cm ²)	26	42.3	-16.3	-16.8	282.24	6.67234
	sm flakes (1-4 cm ²)	81	102.15	-21.15	-21.65	468.7225	4.58857
	med flakes (4-16 cm ²)	82	52.16	29.84	29.34	860.8356	16.503
	lg flakes (16-64 cm ²)	13	7.17	5.83	5.33	28.4089	3.96218
	x-lg flakes (>64 cm ²)	1	0.22	0.78	0.28	0.0784	0.35636
						$\chi^2 =$	43.2677

Tool/Core Analysis Methods

Goals for the statistical analysis from the tool/core data sets collected from the excavations at SPRCQ were to define the patterns of lithic reduction and tool production manifested within these assemblages. Data sets were by the categories of Functional Tools and Shaping-Reduction Tools. As mentioned above, data sets were separated according to excavation units.

The category of Functional tools was devised to clarify the role of expedient tools and what factor they played in the extraction of lithic raw materials. For the analysis of Functional Tools, Chi-square tests were employed to determine if our samples, for each stratum and between the respective quarry pits, are probabilistically from common or different

populations. Scores exceeding the critical Chi-square value for this category would indicate that reduction activities in these levels were centered on creating tools for use in raw material extraction and not for export.

The designation of Shaping-Reduction Tools, devised to measure variation in reduction techniques, was utilized for to clarify the role the production of exportable blanks and bifaces in opposition to tools created for on-site use. Chi-square tests were employed for the analysis of Shaping-Reduction tool assemblages. As in the other analyses, Shaping-Reduction Tools was initiated to ascertain if the samples of these tools, from each stratum and between the quarry pits, were probabilistically from common or different populations. All scores were compared to the Critical values for χ^2 at 0.050 percent. For the statistical analysis of Functional tool/core assemblages from South Paint Rock Chert Quarries, a “Null Hypothesis” was established that the data sets, per stratum, were from a common population. A score exceeding the critical value, coupled with the quantitative data, would help determine the dominant mode of lithic reduction represent through the observed data sets and stratum and that the production of functional tools was consistent throughout all stratum of the specific excavation units.

Likewise, for Shaping-Reduction Tools a “Null Hypothesis” was established that the shaping-reduction tools were from a common population.

Chi-square Analysis for Functional Tool Typology

The Chi-square analyses performed for the category of functional tools (Tables 22-26)

utilized five variables: scrapers (SCR); utilized/retouched flakes (U/R flake); bifaces/bifacially retouched flakes (BF/BF rt); notches/denticulates (N/D); and drills/borers/piercers/choppers/hammerstones (D/B/P/C/H). The types were further categorized by stratum. As mentioned above, excavation units 18N-31E and 75N-39E each contained three distinct stratum where excavation units 24N-31E, 27N-31E, and 83N-38E contained two distinct stratum. Degrees of freedom for both 18N-31E and 75N-39E was calculated at eight ($df = 8$). The degrees of freedom for 24N-31E, 27N-31E, and 83N-38E was calculated at four ($df = 4$). All scores were compared to the Critical values for χ^2 at 0.050 percent. The Chi-square tests for functional tools for 18N-31E, 24N-31E, 27N-31E and 83N-38E were dropped from this analysis due to inadequate sample sizes.

75N-39E functional tools

For this test, a critical value of 15.5073 was needed to reject the null hypothesis. The score recorded was 17.750647, which rejects the null hypothesis (Table 24). The quantitative data reflects a high proportion of functional tools (utilized/retouched flakes, notches/denticulates, and bifaces/bifacially retouched flakes) occurring in Stratum III. The quantity of these tools falls off through Stratum II and I. This leads us to believe that during the extraction of raw materials from this pit, lithic reduction activities were, in part, oriented towards producing expedient/functional tools which were manufactured to aid in the extraction and recovery of chert nodules.

Table 24. 75N-39E Chi-square: functional tools

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/E
stratum 1	SCR	0	0.25	-0.25	-0.75	0.5625	2.25
	U/R flake	9	7.12	1.88	1.38	1.9044	0.2674719
	BF/BF rt	1	2.95	-1.95	-2.45	6.0025	2.0347458
	N/D	3	3.19	-0.19	-0.69	0.4761	0.1492476
	D/B/P/C/H	1	0.49	0.51	0.01	0.0001	0.0002041
stratum 2	SCR	1	0.11	0.89	0.39	0.1521	1.3827273
	U/R flake	4	3.05	0.95	0.45	0.2025	0.0663934
	BF/BF rt	0	1.26	-1.26	-1.76	3.0976	2.4584127
	N/D	0	1.37	-1.37	-1.87	3.4969	2.5524818
	D/B/P/C/H	1	0.21	0.79	0.29	0.0841	0.4004762
stratum 3	SCR	0	0.65	-0.65	-1.15	1.3225	2.0346154
	U/R flake	16	18.82	-2.82	-3.32	11.0224	0.5856748
	BF/BF rt	11	7.79	3.21	2.71	7.3441	0.9427599
	N/D	10	8.44	1.56	1.06	1.1236	0.133128
	D/B/P/C/H	0	1.3	-1.3	-1.8	3.24	2.4923077
						$\chi^2 =$	17.750647

SCR = scrapers, U/R flake = utilized/retouched flake, BF/BF rt = bifaces/bifacially retouched flakes, N/D = notches/denticulates, D/B/P/C/H = drills/borers/piercers/choppers/hammerstones

Chi-square Analysis for Shaping-Reduction Typology

The Chi-square analyses conducted for the category of shaping-reduction tools (Tables 27-31) also adopts five distinct types: non-bifaces/expedient tools (non-BF/EXP tools); shaped bifaces (Sh BF); single/multi-platform cores (S/M-P cores); tested nodules (TN); and bipolar cores (BP cores). The variables were further divided by stratum. As mentioned above, three distinct strata were evident in excavation units 18N-31E and 75N-39E while excavation units 24N-31E, 27N-31E, and 83N-38E contained two distinct strata apiece. Degrees of freedom for both 18N-31E and 75N-39E was calculated at eight ($df = 8$). The degrees of freedom for 24N-31E, 27N-31E, and 83N-38E was calculated at to be four ($df = 4$). All scores were compared to the Critical values for χ^2 at 0.050 percent. The Chi-

square tests for shaping-reduction tools for 27N-31E was dropped from this analysis due to an inadequate sample size.

18N-31E shaping-reduction tools

Chi-square analysis of this unit produced a score of 9.3868887, which is well below the critical value (χ^2) of 15.5073, needed to reject the null hypothesis (Table 25). No clear distinctions between patterns of shaping-reduction tool manufacture can be seen throughout the stratum or from the S-R tool assemblages recovered from this unit. Within all three strata of this unit, quantitative data would suggest that the dominant mode of lithic extraction for shaping-reduction activities was centered on the production of single and multi-platform cores with the testing of nodules playing a secondary role.

Table 25. 18N-31E Chi-square: shaping-reduction tools

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/E
stratum 1	non-BF/EXP tools	2	2.11	-0.11	-0.61	0.3721	0.1763507
	S BF	0	0.42	-0.42	-0.92	0.8464	2.0152381
	S/M-P cores	28	28.25	-0.25	-0.75	0.5625	0.0199115
	TN	7	5.9	1.1	0.6	0.36	0.0610169
	BP cores	6	6.32	-0.32	-0.82	0.6724	0.1063924
stratum 2	non-BF/EXP tools	3	2.25	0.75	0.25	0.0625	0.0277778
	S BF	1	0.45	0.55	0.05	0.0025	0.0055556
	S/M-P cores	29	30.22	-1.22	-1.72	2.9584	0.0978954
	TN	5	6.31	-1.31	-1.81	3.2761	0.5191918
	BP cores	8	6.76	1.24	0.74	0.5476	0.0810059
stratum 3	non-BF/EXP tools	0	0.64	-0.64	-1.14	1.2996	2.030625
	S BF	0	0.13	-0.13	-0.63	0.3969	3.0530769
	S/M-P cores	10	8.54	1.46	0.96	0.9216	0.1079157
	TN	2	1.78	0.22	-0.28	0.0784	0.0440449
	BP cores	1	1.91	-0.91	-1.41	1.9881	1.0408901
						$\chi^2 =$	9.3868887

non-BF/EXP tools = non-bifaces/expedient tools, Sh BF = shaped bifaces, S/M-P cores = single/multi-platform cores, TN = tested nodules, BP cores = bipolar cores

24N-31E shaping-reduction tools

For the shaping/reduction tool analysis for this unit a critical value (χ^2) greater than 9.48773 was needed to reject the null hypothesis. A score of 10.193642 was determined (Table 26). This score rejects the null hypothesis, indicating that the production of shaping-reduction tools from this unit was not consistent between strata. A large number of single and multi-platform cores in Stratum I is not compatible to the relatively low numbers throughout Stratum II.

Further investigation and excavations around 24N-31E would help to elucidate the exact extent of this reduction episode and help to determine if the concentration of cores in

Stratum I were the result of exhausted materials and pit abandonment or redeposition of materials into the pit by erosional or cleaning/dumping episode.

Table 26. 24N-31E Chi-square: shaping-reduction tools

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/I
stratum 1	non-BF/EXP tools	7	6.94	0.06	-0.44	0.1936	0.027896
	S BF	3	2.43	0.57	0.07	0.0049	0.002016
	S/M-P cores	25	24.3	0.7	0.2	0.04	0.001646
	TN	3	5.21	-2.21	-2.71	7.3441	1.409616
	BP cores	8	6.94	1.06	0.56	0.3136	0.045187
stratum 2	non-BF/EXP tools	1	1.06	-0.06	-0.56	0.3136	0.295849
	S BF	0	0.4	-0.4	-0.9	0.81	2.02
	S/M-P cores	3	3.7	-0.7	-1.2	1.44	0.389189
	TN	3	0.79	2.21	1.71	2.9241	3.701392
	BP cores	0	1.06	-1.06	-1.56	2.4336	2.295849
						$\chi^2 =$	10.19364

non-BF/EXP tools = non-bifaces/expedient tools, Sh BF = shaped bifaces, S/M-P cores = single/multi-platform cores, TN = tested nodules, BP cores = bipolar cores

75N-39E shaping-reduction tools

For the shaping-reduction tool analysis for this unit, a critical value (χ^2) greater than 15.5073 was needed to reject the null hypothesis. A score of 23.621742 was recorded causing the null hypothesis to be rejected, indicating that the production of shaping-reduction tools was variable throughout the strata of this unit (Table 27). An investigation of the quantitative data suggests that within Stratum III single and multi-platform cores were being reduced with the intent of producing bifaces and expedient tools. This inference comes from a small number of shaped bifaces recovered from this stratum, in conjunction with higher than

expected numbers of bend initiation flakes (see Table 15) and a high number of single/multi-platform cores, would indicate that early stage bifaces were being exported off site for further refinement. Reduction strategies appear to have shifted in the upper levels of this unit (Stratum I & Stratum II). Single and multi-platform cores from the first two strata occur in lower numbers than expected, while the numbers of non-bifaces is higher than expected. The quantitative data suggests that the focus of reduction activities shifted from the production of bifaces, in the earliest strata, to the production of expedient, possibly quarrying, tools in the latter stages of raw material extraction at quarry pit #7.

Table 27. 75N-39E Chi-square: shaping-reduction tools

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/E
stratum 1	non-BF/EXP tools	13	7.24	5.76	5.26	27.6676	3.821491
	S BF	1	1.98	-0.98	-1.48	2.1904	1.106262
	S/M-P cores	20	25.52	-5.52	-6.02	36.2404	1.420078
	TN	0	0.66	-0.66	-1.16	1.3456	2.038787
	BP cores	7	5.6	1.4	0.9	0.81	0.144642
stratum 2	non-BF/EXP tools	4	1.24	2.76	2.26	5.1076	4.119032
	S BF	1	0.34	0.66	0.16	0.0256	0.075294
	S/M-P cores	1	4.36	-3.36	-3.86	14.8996	3.417339
	TN	1	0.08	0.92	0.42	0.1764	2.200000
	BP cores	0	0.96	-0.96	-1.46	2.1316	2.220416
stratum 3	non-BF/EXP tools	27	35.52	-8.52	-9.02	81.3604	2.290551
	S BF	10	9.69	0.31	-0.19	0.0361	0.003725
	S/M-P cores	134	125.12	8.88	8.38	70.2244	0.561256
	TN	3	3.23	-0.23	-0.73	0.5329	0.164984
	BP cores	27	27.45	-0.45	-0.95	0.9025	0.03287
						$\chi^2 =$	23.62174

non-BF/EXP tools = non-bifaces/expedient tools, Sh BF = shaped bifaces, S/M-P cores = single/multi-platform cores, TN = tested nodules, BP cores = bipolar cores

83N-38E shaping-reduction tools

For the Chi-square analysis for shaping-reduction tools from this unit a critical value (χ^2) greater than 9.48773 was needed to reject the null hypothesis. A score of 19.37596 was recorded as a result of this test (Table 28) indicating significance. Quantitative and statistical data from Stratum I of 83N-38E, compared with the same data from Stratum I of 75N-39E, suggests a spatial and temporal relationship between the production of expedient tools from these units.

Table 28. 83N-38E Chi-square: shaping-reduction tools

		O	E	O-E	(O-E)-0.5	SQUARE	SQUARE/E
stratum 1	non-BF/EXP tools	10	7.41	2.59	2.09	4.3681	0.589487
	S BF	1	1.35	-0.35	-0.85	0.7225	0.535185
	S/M-P cores	15	15.5	-0.5	-1	1	0.064516
	TN	1	0.67	0.33	-0.17	0.0289	0.043134
	BP cores	4	6.07	-2.07	-2.57	6.6049	1.088121
stratum 2	non-BF/EXP tools	1	3.59	-2.59	-3.09	9.5481	2.659637
	S BF	1	0.65	0.35	-0.15	0.0225	0.034615
	S/M-P cores	8	7.5	0.5	0	0	0
	TN	0	0.02	-0.02	-0.52	0.2704	13.52
	BP cores	5	2.93	2.07	1.57	2.4649	0.841262
						$\chi^2 =$	19.37596

non-BF/EXP tools = non-bifaces/expedient tools, Sh BF = shaped bifaces, S/M-P cores = single/multi-platform cores, TN = tested nodules, BP cores = bipolar cores

Correlation Tests

Bivariate Correlation tests were conducted for the analysis of the lithic assemblage from SPRCQ to help measure the relation between flake and core types. Each of these

variables was divided into three types for this test. They are based on the cone (hard hammer flakes), bend (soft hammer flakes), and wedge (bipolar flakes) initiations that were paired from the categories of core, bifaces and bipolar cores respectively.

For the analysis of cone initiation flakes and cores it was assumed that the measure of the correlation between these variables would provide details as to the degree by which cores were transported from the site or used on site to produce tools for quarrying activities. Likewise, as with the previous analysis, it was assumed a bend initiation flake to biface analysis would provide analogous information as to the role of bifaces at this site and whether they were produced for site use or to be transported off. And finally, it was concluded that this analysis of the remaining variables would clarify the relationship between wedge initiation flakes and bipolar cores and whether these artifacts were produced for on-site use or for transport off.

In order to run the correlation test quantitative data was needed for the variables to be paired for each test. The numbers for each test were established by dividing the total number of initiation types (cone, bend, wedge) by the total number of all platform bearing flakes. The numbers for the corresponding variables for the initiation types were calculated by dividing the number of core types (core, biface, bipolar) by the total number of all cores plus tools. Numerical computations for these variables were determined for every stratum in each of the five excavation units (see Tables 36-38 for these figures). The degrees of freedom for all of the excavation units were calculated at one ($df=1$). All scores were compared to the critical values for the Pearson product-moment correlation table at 0.050 percent.

Table 29. Cone Initiation Flakes and Cores

Stratum 1	cone init. Flakes	all flakes w/platform	cone init. / all plat flks.	all cores (no BP)	all Cores + all Tools	cores / all core + tools
18N-31E	57	74	.77	35	37	.95
24N-31E	37	56	.66	28	38	.74
27N-31E	91	151	.60	17	24	.71
75N-39E	136	151	.90	20	34	.59
83N-38E	61	101	.60	16	27	.59
Stratum 2						
18N-31E	75	117	.64	34	38	.89
24N-31E	15	20	.75	6	7	.86
27N-31E	2	2	1	0	0	0
75N-39E	73	94	.78	2	7	.29
83N-38E	28	32	.88	8	10	.80
Stratum 3						
18N-31E	14	22	.64	12	12	1
75N-39E	271	379	.72	137	174	.79

Table 30. Bend Initiation Flakes and Bifaces

Stratum 1	bend init. flakes	all flakes w/platform	bend init. / all plat flks.	all bifaces	all Cores + all Tools	bifaces / all core + tools
18N-31E	17	74	.23	0	37	0
24N-31E	17	56	.30	2	38	.05
27N-31E	54	151	.36	2	24	.08
75N-39E	15	151	.10	1	34	.03
83N-38E	39	101	.39	0	27	0
Stratum 2						
18N-31E	36	117	.31	1	38	.03
24N-31E	5	20	.25	0	7	0
27N-31E	0	2	0	0	0	0
75N-39E	17	94	.18	0	7	0
83N-38E	4	32	.13	1	10	.1
Stratum 3						
18N-31E	8	22	.36	0	12	0
75N-39E	106	379	.28	10	174	.06

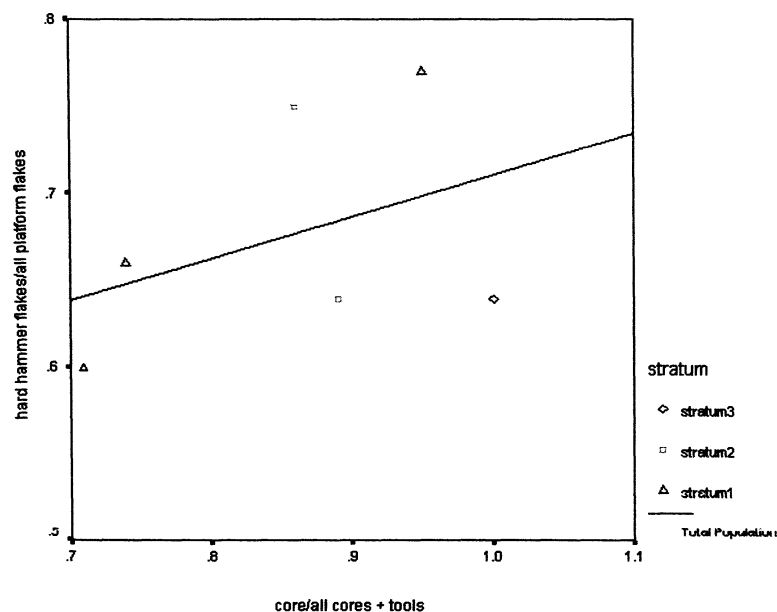
Table 31. Wedge Initiation Flakes and Bipolar Cores

Stratum 1	wdge init. Flakes	all flakes w/platform	wdge init. / all plat flks.	bp cores	all Cores + all Tools	bp core / all core + tools
18N-31E	0	74	0	6	37	.16
24N-31E	2	56	.04	8	38	.21
27N-31E	6	151	.04	11	24	.46
75N-39E	0	151	0	7	34	.21
83N-38E	1	101	.01	4	27	.15
Stratum 2						
18N-31E	6	117	.05	8	38	.21
24N-31E	0	20	0	0	7	0
27N-31E	0	2	0	0	0	0
75N-39E	4	94	.04	0	7	0
83N-38E	0	32	0	5	10	.50
Stratum 3						
18N-31E	0	22	0	1	12	.08
75N-39E	2	379	.01	27	174	.16

Quarry Pit #4 - Cone Initiation Flakes vs. Cores

As mentioned above, this test was devised to discern the role of core production and the extent by which cores were transported from 48BH245. Excavation units 18N-31E, 24N-31E, and 27N-31E were located on the southern berm, northern interior and northern exterior of Quarry Pit #4 respectively. Six variables were paired together for this test. Numerical designations for the variables (see Table 29) were calculated by taking the observed figure for cone initiation flakes and dividing it by the observed number of all platform bearing flakes. This figure was paired with a numerical value for all observed cores (except bipolar cores) divided by the observed number of all cores plus tools (except hammerstones). Stratum II from unit 27N-31E was excluded from this test because no cores were recovered from this stratum negating the pairing of this category with the flake category. These numbers were then plotted by a correlation program which produces the following results (Figure 18).

Figure 18. Scatterplot QP#4 Cone Initiation (hard hammer) Flakes and Cores



Correlations Results - Quarry Pit #4: Cone Initiation Flakes & Cores

As can be seen in Figure 18, a positive correlation exists between the production of cone initiation flakes and cores. The score for the value of r was calculated at .404 indicating a moderate relationship between these two variables.

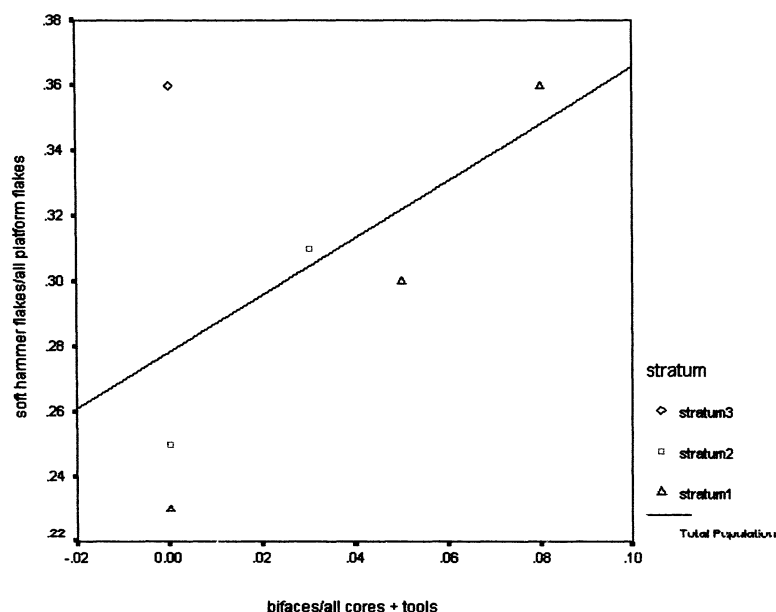
As seen through the materials recovered from Stratum I of the units excavated near Quarry Pit #4, high levels of cone initiation flakes correspond to high levels of cores indicating that the extraction of workable cores for reduction was the primary quarrying goal within this strata. A positive correlation, or strong relationship between the variables for this test, can be seen from the materials recovered from Stratum I, as manifested through the

scatterplot data (Figure 18). The quantitative figures also confirm that within the three strata, excavated in association with Quarry Pit #4, high numbers of cone initiation flakes and cores were recovered. This supports the conclusion that lithic reduction activities in this area were focused on the extraction and refinement of cores, in all likelihood to produce workable flakes and/or blanks. The relationship between the variables within Stratum II and Stratum III is less clear. No positive correlation can be seen from the variables within these two strata. With only one sample set recovered from Stratum III (18N-31E), this strata yielded little information as to the measure of relationship between the two variables for this test.

Quarry Pit #4 - Bend Initiation Flakes vs. Bifaces

Methods for this analysis were identical as discussed in the cone initiation/core test except for the change in variables. Six paired variables were devised for this test. Numerical designations for the variables (see Table 30) were calculated by taking the observed figure for bend initiation flakes and dividing it by the observed number of all platform bearing flakes. This figure was paired with a numerical value for all observed bifaces which was divided by the observed number of all cores plus tools (except hammerstones). These numbers were then plotted by a correlation program which produced the following results (Figure 19).

Figure 19. Scatterplot QP#4 Bend Initiation (soft hammer) Flakes and Bifaces



Correlations Results - Quarry Pit #4: Bend Initiation Flakes & Bifaces

The results from this analysis (Figure 19) show a positive correlation between the two variables used in this test. The score for the value of r was calculated at .536 indicating a moderate relationship between these bend initiation flakes and bifaces for Quarry Pit #4.

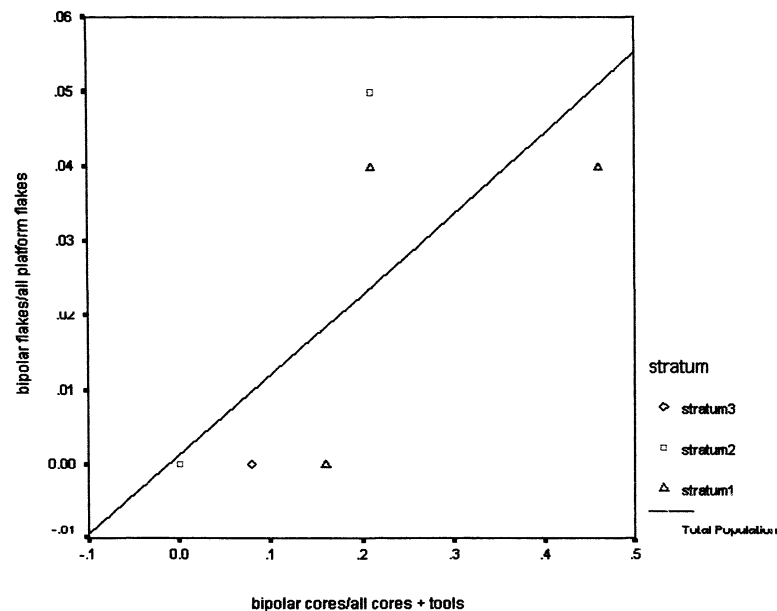
A positive correlation can be seen between bend initiation flakes and bifaces from Stratum I and Stratum II of this test (see figure 19). Within Stratum I, concentrations of bend initiation flakes are greatest within 27N-31E. Although there is a positive correlation between the variables for Stratum II, the relative frequency is smaller. Quantitative figures of bend initiation flakes coupled with low numbers of recovered bifaces indicates that while the

production of bifaces was a part of the lithic procurement and reduction activities occurring near this quarry pit, once bifaces were minimally worked they were transported off site for further refinement. Only one unit produced data from Stratum III of this test (18N-31E). Its position in relation to the line of best fit in the scatterplot indicates that it is an outlier. Its exact meaning or relation to this analysis is unclear. Looking at the data in quantitative terms, it does coincide with earlier conclusions in that biface production was represented in the assemblages collected but that it was minimal and bifaces were transported off site.

Quarry Pit #4 - Wedge Initiation Flakes vs. Bipolar Cores

Methods for this analysis were identical as discussed in the previous analyses except for the change in variables. Seven sets of paired values were employed for this test. Values (see Table 31) were calculated by taking the observed figure for wedge initiation flakes and dividing it by the observed number of all platform bearing flakes. This figure was paired with a numerical value for all observed bipolar cores that was divided by the observed number of all cores plus tools (except hammerstones). These numbers were then analyzed by a correlation program which produced the following graph (Figure 20).

Figure 20. Scatterplot QP#4 Wedge Initiation (bipolar) Flakes and Bipolar Cores



Correlations Results - Quarry Pit #4: Wedge Initiation Flakes & Bipolar Cores

The results from this analysis (Figure 20) show a positive correlation between the wedge initiation flakes and bipolar cores. The score for the value of r was calculated at .737 indicating a moderately strong relationship between two variables for this test.

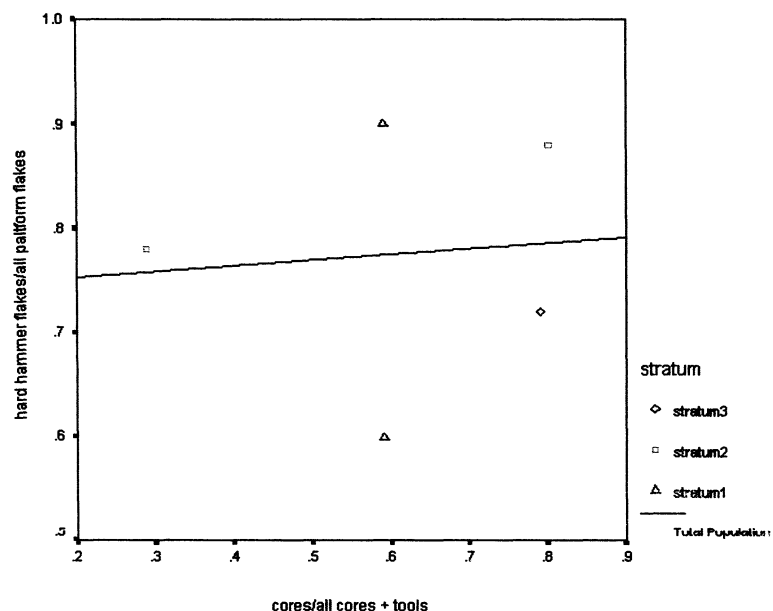
Low levels of wedge initiation flakes and bipolar cores were recovered during the excavations at SPRCQ. The test of correlation between wedge initiation flakes and bipolar cores indicates that bipolar reduction did occur at this quarry pit but in numbers not significant enough to suggest this reduction activity was anything more than a means of producing flakes for immediate use in the area. The export of bipolar flakes or cores from

this unit was highly unlikely. Quantitative figures are low enough to assume that bipolar products were used on site for expedient purposes in quarrying activities.

Quarry Pit #7 - Cone Initiation Flakes and Cores

This test was analogous to the tests for Quarry Pit #4. It was hoped that this test would also clarify the role of core production in association with this quarry pit and the extent by which cores were transported from 48BH245. Excavation units 75N-39E and 83N-38E were placed on the southern and northern berm of Quarry Pit #7 respectively. Five sets of values were employed for this test. Values (see Table 29) were calculated by taking the observed figure for cone initiation flakes and dividing it by the observed number of all platform bearing flakes. This figure was paired with a numerical value for all observed cores (except bipolar cores) divided by the observed number of all cores plus tools (except hammerstones). These numbers were then analyzed by a correlation program which produced the following graph (Figure 21).

Figure 21. Scatterplot QP#7 Cone Initiation (hard hammer) Flakes and Cores



Correlation Results - Quarry Pit #7: Cone Initiation Flakes & Cores

As can be seen in Figure 21, a zero correlation exists between the production of cone initiation flakes and cores for this unit. The score for the value of r was calculated at .093 which shows an almost total lack of correlation between the variables from this test.

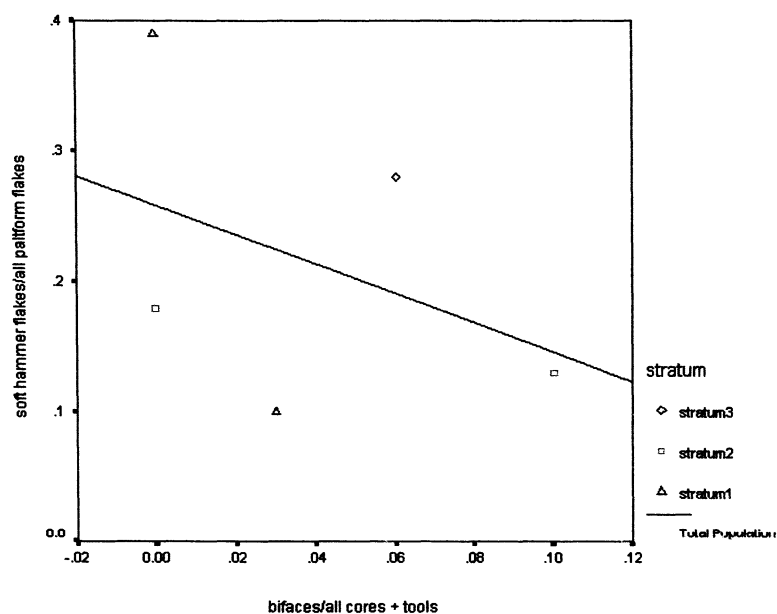
The results for this test, coupled with the quantitative data, indicate a complex relationship between the assemblages recovered from these two excavation units. Although the results for this test demonstrated a lack of correlation between cone initiation flakes and cores, but it is clear through the flake typologies that cores were being removed and refined from this quarry pit. The volume of cores recovered increased dramatically from the previous

two strata in Stratum III and the amount of cone initiation flakes recovered corresponded with the increased number of cores recovered. Without the benefit of an affirmation of the correlation test, but looking at the numbers alone, we can conclude that core extraction did occur at this quarry pit and the subsequent reduction of these cores produced the copious amounts of cone initiation flakes recovered from the two test units excavated in proximity to Quarry Pit #7.

Quarry Pit #7 - Bend Initiation Flakes vs. Bifaces

As in the previous test, five sets of variables were employed for this analysis. Numerical designations for the variables (see Table 30) were calculated by taking the observed figure for bend initiation flakes and dividing it by the observed number of all platform bearing flakes. This figure was paired with a numerical value for all observed bifaces which was divided by the observed number of all cores plus tools (except hammerstones). These figures were then plotted by a correlation program which calculated the following graph (Figure 22).

Figure 22. Scatterplot QP#7 Bend Initiation (soft hammer) Flakes and Bifaces



Correlations Results - Quarry Pit #7: Bend Initiation Flakes & Bifaces

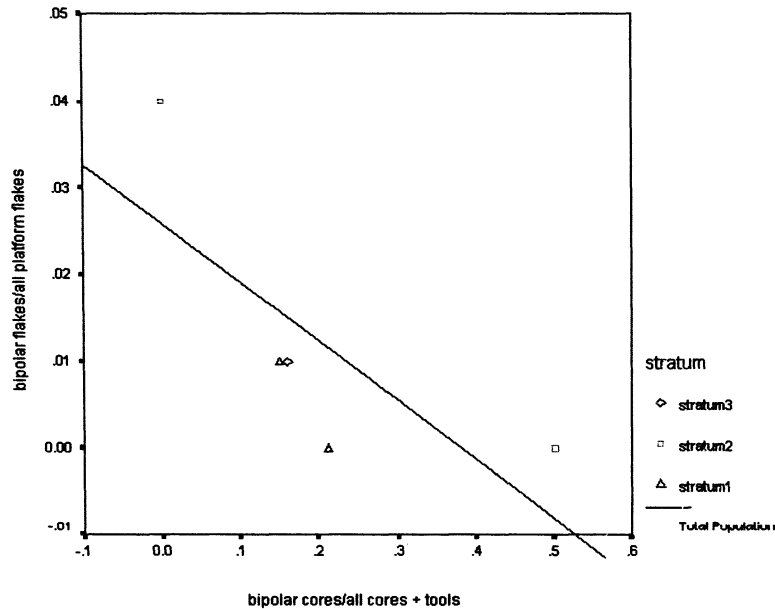
The results from this analysis (Figure 22) shows a negative correlation between the two variables used in this test. The score for the value of r was calculated at $-.406$ indicating a moderately weak relationship between these two variables for Quarry Pit #7. In Quarry Pit #7, levels of bend initiation flakes increase from Stratum I to Stratum II as level for bifaces decrease. This can be seen as indicating that bifaces were being produced for export in Stratum I & II. This is evident in high levels of flakes coupled with low levels of bifaces recovered from these strata. Biface reduction became less prevalent in Stratum I. Stratum III from 75N-39E is an outlier in this test, with high levels of bend initiation flakes to bifaces

this could possibly indicate that bifaces were also being worked in this strata for export purposes.

Quarry Pit #7 - Wedge Initiation Flakes vs. Bipolar Cores

Methods for this test were conducted according to the manner discussed in the previous analyses except for the change in variables. Five paired sets of variables were also employed in this test. Numerical designations for the variables (see Table 31) were calculated by taking the observed figure for wedge initiation flakes and dividing it by the observed number of all platform bearing flakes. This figure was paired with a numerical value for all observed bipolar cores which was divided by the observed number of all cores plus tools (except hammerstones). These numbers were then analyzed by a correlation program which plotted the following graph (Figure 23).

Figure 23. Scatterplot QP#7 Wedge Initiation (bipolar) Flakes and Bipolar Cores



Correlations Results - Quarry Pit #7: Wedge initiation Flakes & Bipolar Cores

The results from this analysis show a negative correlation between the two variables from test. The score for the value of r was calculated at $-.759$ indicating a moderately strong relationship between two variables of this quarry pit (Figure 23).

Stratum I exhibits the classic negative correlation. As numbers of wedge initiation flakes rose, the number of bipolar cores fell. This also occurred in Stratum II with high levels of wedge initiation flakes corresponding to low numbers of bipolar cores. Stratum III exhibits a more balanced distribution of wedge initiation flakes and cores. Either the resulting flakes were used as expedient tools in the quarry and rendered unidentifiable after use, or bipolar

cores were transported off site and worked elsewhere. In Stratum II no bipolar cores were identified and a minimal amount of flakes recovered, it is likely that the wedge initiation flakes were the result of a need for an expedient cutting. Stratum III had a comparatively high number of bipolar cores, coupled with a low number of wedge initiation flakes indicating that bipolar reduction was not occurring at this stratum but that bipolar cores were being produced for later transport off site.

Possible explanations for the negative correlation for this test are that the numbers of wedge initiation flakes, coupled with the data for bipolar cores indicates that either the bipolar cores produced were demolished during reduction episodes or were produced and then transported off site for later use.

CHAPTER FIVE

CONCLUSIONS

The 1998 Archaeological field school at 48BH245 in the South Paint Rock Chert Quarries excavated five units in association with Quarry Pit #4 and Quarry Pit #7. During the excavations a total of 14,468 artifacts were unearthed. A diverse assortment of artifacts were recovered but by far the largest category of items recovered were flakes. Artifact types identified during lithic analysis include bifaces, hammerstones, utilized and retouched flakes, denticulates and notches, a drill/borer, pieces esquillée and cores. Core assemblages included multi-platform spheroid, bipolar and single platform prepared block cores. Through the analysis of lithic assemblages from South Paint Rock Chert Quarries in general and 48BH245 specifically we had hoped to clarify the roles of (1) lithic quarry site formation processes and lithic tool production sites; (2) develop a better understanding of technological organization concerning lithic procurement within hunter-gatherer economies; and (3) to aid in the development of the understanding of Great Plains and intermontane hunter-gatherer cultures.

As stated in the introduction of this paper, the primary goal of this analysis of lithic assemblages from South Paint Rock Chert Quarries was to clarify how prehistoric populations exploited chert as a raw material for tool manufacture. The chert quarries at South Paint Rock are significant in that they contain sizable stratified deposits allowing a atypical opportunity to study prehistoric quarrying variation through time. In order to assess the character and meaning of the artifact assemblages recovered from the summer field season and how they related to on- site lithic reduction strategies, we must consider the context of

these assemblages in respect to the specific quarry pits and strata from which each was recovered. This was accomplished in part by statistical analyses utilizing Chi-square and Correlation tests. The following discussion will summarize the broad patterns and results observed, as result of the statistical analyses, and then discuss the implications of these conclusions in relation to the research goals stated at the beginning of this thesis.

LITHIC ANALYSES SUMMARY

Quarry Pit #4

Three excavation units were placed at Quarry Pit #4 (QP#4) on the southern berm (18N-31E), northern interior (24N-31E), and northern exterior (27N-31E). The Chi-square analysis of initiation types and platform angles from lithic materials recovered from QP #4 indicate that lithic reduction activities were fairly uniform. Quantitative figures from initiations from 18N-31E, 24N-31E, and 27N-31E would tentatively suggest that hard hammer reduction was the primary technique used in reduction activities for the strata excavated from these units.

Tool assemblages found in association with Quarry Pit #4 were dominated by expedient tools like notches and denticulates, effective for producing quarrying tools like digging sticks, and hammerstones, used in lithic reduction. Out of six chi-square tests for functional and shaping-reduction tools, one test exceeded the established critical value; this was the test for the functional tools from 24N-31E. No clear distinctions between patterns

of functional tools or shaping-reduction tools could be discerned by the chi-square tests for these variables.

Correlation analyses from Quarry Pit #4 for cone initiation vs. cores, bend initiation vs. bifaces and wedge initiation vs. bipolar cores resulted in positive correlations with moderate relationship for the first two groups of paired variables and a moderately strong relationship for the last set of paired variables. The positive correlation obtained for the test in conjunction with high numbers of cone initiation flakes and single and multi-platform cores from QP#4 indicates that cores were extracted and reduced on site, in all likelihood with the goal of producing workable blanks which were then transported off site for further refinement.

The correlation analysis for bend initiation vs. bifaces has shown that within Stratum I and Stratum II biface production was evident from the material collected from this quarry pit. Low numbers for both of these variable in conjunction with a positive correlation would suggest that bifaces were minimally worked and that biface production was a secondary goal of lithic production within this. The data from Stratum III is a strong positive correlation and indicates that bifaces worked in this strata were transported off-site.

For wedge initiation vs. bipolar cores, the correlation test show that bipolar reduction techniques were evident within this quarry pit to a lesser degree than core reduction or biface production. Low quantitative figures imply that this method for lithic reduction was little used, but a strong correlation supports bipolar reduction as an *in-situ* activity for expedient purposes.

Quarry Pit #7

Quarry Pit #7 was more enlightening as to quarrying processes at 48BH245. Whereas data from the excavation units on QP #4 indicated a single consistent technique, evidence from 75N-39E suggested several different reduction episodes evident at this quarry pit. Excavation units 75N-39E and 83N-38E were placed on the southern and northern berms of Quarry Pit #7. Chi-square analyses for initiation types, functional tools and shaping-reduction tools for 75N-39E and initiation types and shaping-reduction tools from 83N-38E were positive, warranting four additional chi-square tests for flake size and flake cortex percentage, which were also positive.

Data from the chi-square test for initiations from 75N-39E indicates that within Stratum III, lithic reduction activities were oriented towards the production of bifaces and tools. Stratum I and II chi-square data from this unit indicates that reduction activities are centered on core reduction. Within 83N-38E reduction activities in the Stratum II are geared towards core reduction with a shift in Stratum I to biface/tool production. For both 75N-39E and 83N-38E the chi-square tests for platform angles failed to exceed the critical values established for the test.

With the results of the first round of chi-square test, a second series of tests were devised to clarify and further illuminate the context of quarrying activities from Quarry Pit #7. These were tests for dorsal Cortex Percentage and Flake Size. All critical values were exceeded for these four tests. Data from the analysis of flake cortex percentage from 75N-39E confirms earlier conclusions gathered from initiations. From these data we see that within Stratum III lithic reduction was directed towards the production of bifaces and tools.

A transition from biface production to core reduction occurs in Stratum II and I. The cortex percentage test from 83N-38E also confirms conclusions drawn from initiations for this unit. The test shows that lithic reduction activities in Stratum II were centered on core reduction while Stratum I materials indicate a principal orientation towards biface/blank production.

Flake size data for 75N-39E confirms earlier conclusions as to reduction activities. Within the Stratum III of this unit, higher than expected numbers of large (16-64 cm²) and extra-large (>64 cm²) flakes were recovered indicating that cores were being reduced to produce flakes, which were likely transported off site for further refinement. In Stratum II we see a shift in reduction activities in that numbers fall for large (16-64 cm²) and extra-large (>64 cm²) flakes while greater than expected numbers for extra-small (<1 cm²) and medium (4-16 cm²) flakes were observed. These size flakes indicator that reduction activities were centered on core reduction. Stratum I quantitative figures would suggest that core reduction was the dominant reduction activity in this strata

In the chi-square analysis for tools for Quarry Pit #7, critical values were achieved in three of the four tests. For the Functional Tool category from 75N-39E, the data indicate that the production of these implements was consistent throughout all strata, suggesting these objects were produced to aid in the quarrying process. This was also true of shaping-reduction tools within the stratum of 75N-39E where these tools were produced. For 83N-38E the chi-square test for functional tools failed to exceed the critical value indicating that there was no significant variation in production between the strata of this unit. The test for shaping-reduction tools for 83N-38E was positive, demonstrating variation in tool discard throughout all strata of this unit.

Correlation analyses from Quarry Pit #7 for cone initiation vs. cores, bend initiation vs. bifaces and wedge initiation vs. bipolar cores resulted in a zero correlation and two negative correlations respectively. The correlation tests for bend initiation vs. bifaces was moderately weak, as where the test for wedge initiations was moderately strong. The correlation test for cone initiations vs. cores showed an almost total lack of correlation between these two variables. Without the confirmation of the correlation test, but looking at the previous analyses coupled with the quantitative figures, it is clear that core reduction was discernible within this quarry pit.

The moderately weak negative correlation for the analysis of bend initiation flakes vs. bifaces shows that as numbers of bend initiation flakes rose within Stratum II & I of these units, the subsequent bifaces recovered declined. This is a clear indicator that the by-products of biface production were transported elsewhere for use or retouch. Stratum III from 75N-39E was an outlier in this test, with high levels of bend initiation flakes to bifaces this could possibly indicate that bifaces were also being worked in this strata for export purposes.

The test for wedge initiation flakes vs. bipolar cores resulted in a moderately strong negative correlation. Stratum I is the main contributor of this pattern. As numbers of wedge initiation flakes rose, the number of bipolar cores fell. This also occurred in Stratum II with high levels of wedge initiation flakes corresponding to low numbers of bipolar cores. Stratum III exhibits a more balanced distribution of wedge initiation flakes and cores. Either the resulting flakes were used as expedient tools in the quarry and rendered unidentifiable after use, or bipolar cores were transported off site and worked elsewhere. A possible explanation for the negative correlation for this test is either the bipolar cores produced were demolished

during reduction episodes or were transported off site for later use. It is likely that the wedge initiation flakes recovered from this quarry pit were the result of a need for an expedient cutting tool.

SUMMARY OF RESEARCH

A comparison between the 1998 University of Montana Archaeological Field School and earlier work conducted by Light and Prentiss (1993) and Prentiss (1994) shows that they achieved similar results. Both investigations demonstrated that stratigraphy remained intact throughout tested areas and was not altered through erosional or depositional events. The summer excavations at SPRCQ confirmed earlier conclusions that lithic assemblages from 48BH245 were dominated by debitage and several variants of cores. Conclusions drawn from the examination of lithic assemblages indicates that reduction activities from each quarry pit varied spatially and were organizationally distinct strategies focused on producing different lithic types. The analysis of lithic materials from Quarry Pit #4 indicated a primary emphasis on the reduction of cores to produce large flakes for export. The investigation of materials from Quarry Pit #7 showed a dual focus on the reduction of cores and production of early stage bifaces. Bifaces were produced from this quarry pit and exported off-site for use or further reduction. It is likely that some cores were also worked and transferred off site for future use.

Reher (1991) has stated, in regards to his work at Spanish Diggings in southeast Wyoming, that the central problem with archaeological investigations at quarry sites is the identification of temporal living surfaces which were focused on quarrying and lithic reduction

activities due to the vast amounts of lithic materials present in a quarrying site. While this is certainly true, the intact stratigraphy at South Paint Rock Chert Quarries has provided a succinct glimpse into the workings of prehistoric quarrying and lithic reduction activities through the excavations undertaken by the 1998 University of Montana Summer Archaeological Field School. For this thesis, statistical analyses have helped to delineate and confirm a small part of the activities and strategies which produced the lithic materials collected and observed during the excavations.

This work demonstrates that further research at this site is warranted. The excavations from the summer of 1998 only scratched the surface of a quarrying complex which was likely in use from at least the Middle Archaic up to the Late Prehistoric Periods. Additional research will better illuminate occupational variation and patterning as well as define the likely quarrying strategies. Future research in this area can clarify the variations seen between quarry pit occupations, identify single use vs. multiple use episodes, and illuminate the role and character of lithic quarrying on the Northwest Plains.

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